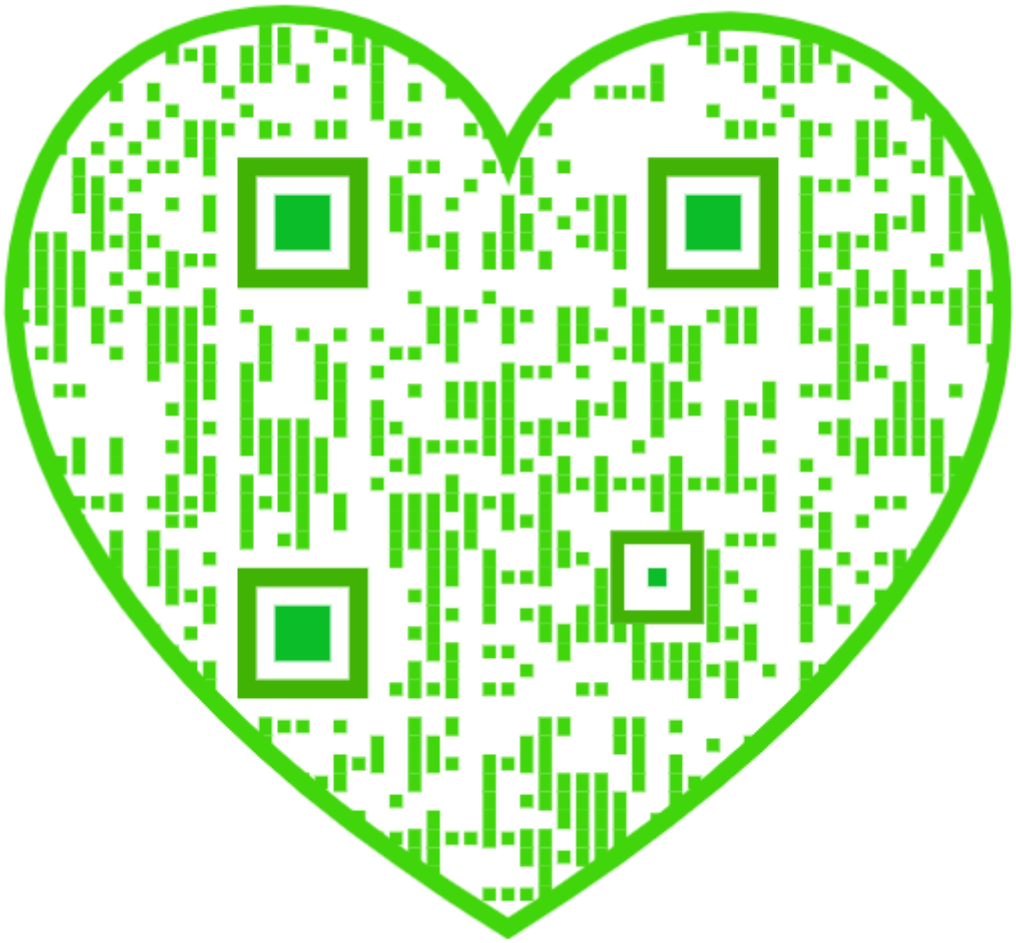

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WAR AND THE WEATHER.

BY

EDWARD POWERS. C. E.

REVISED EDITION.

DELAVAN, WIS.
E. POWERS.
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PREFACE TO THE REVISED EDITION.

THE first edition of this book was published in Chicago in 1871, a short time before the occurrence of the great fire which swept away so large a portion of that city, and the greater part of it was destroyed in that conflagration, together with the stereotype plates. It was not republished; but the author adopted, instead, the plan of bringing his subject forward by means of public lectures. Other matters, however, prevented a continuance of this; and his plan for benefiting the human race, and more especially the farmers of America, has, for many years, been held in abeyance. In view, however, of the attention which has been directed in recent years to schemes of irrigation for the arid regions of the West and the manifest impossibility of supplying, in that way, the needs of vast sections of the country where the rainfall is never sufficient; in view, also, of the often recurring drouths that afflict even those portions of the country which are the most highly favored by nature—it is believed that the present is an appro-

priate time for again calling attention to a means of relief as yet untried, but which has in it a promise of most beneficent results.

DELAVAN, WIS., Sept. 1, 1890.

WAR AND THE WEATHER.

THE idea that rain can be produced by human agency, though sufficiently startling, is not one which, in this age of progress, ought to be considered as impossible of practical realization. Aside from its connection with the superstitions of certain savage tribes, it is an opinion of comparatively recent origin, and is one which cannot be regarded as belonging, in any degree, to a certain class of notions which prevail among the unthinking, and which, being based neither on reason nor observed facts, are respectable, if at all, only for their antiquity; but, on the contrary, it is one which is confined principally to those who are accustomed to draw conclusions only from adequate premises, and whose belief in the matter referred to has generally been founded on facts which have come under their own observation. When numerous observers, each independently of the others, arrive at an identical conclusion, in reasoning from facts which they have separately noticed in widely different fields, such conclusion is certainly worthy of respect, and may be assumed to contain the elements of truth. Of this nature is the idea under consideration -- the

belief that rain has been, and can be, brought on by heavy discharges of artillery.

In collecting some of the facts bearing on this question and submitting them to the public, the object of the writer has been to awaken a more general interest in the subject, in the hope that Congress may be induced to cause some experiments to be made for the purpose of developing the natural principle that seems to be involved, and determining if it cannot be made of practical use to the country. If it should be conceded — as it must be from the evidence that will be presented — that battles have produced changes in the weather, it would seem to be an eminently proper subject for legislative action to provide for an investigation of the conditions under which these changes can be made. If lightning and thunder and rain have been brought on by the agency of man, when bloodshed and slaughter only were intended, this surely can be done without these latter concomitants. And when we consider the grand results that would flow from an assured power and well defined method of causing rain to fall at will — the mighty step that would thereby be made by man towards the complete control over nature to which he aspires — the bare possibility that such a power, heretofore considered as a prerogative of the Deity alone, is within his reach, ought to be sufficient to

lead to an earnest inquiry into the truth of the matter, and to an investigation as to the most economical and effective means of applying it, if it should be found to exist. That there is the strongest reason for believing that this achievement is possible, I have the means of showing; but to verify the truth of the theory by which such power is claimed, and to determine its limits and conditions, can only be done by a well regulated series of experiments with powder and cannon and other appliances. Such experiments, when made, as eventually they surely will be, should be made at the public expense; for it is the public who would be benefited in the event of their success. The art of regulating the weather to some extent, if such an art should ever be acquired, is not one on which a patent could ever be obtained, nor would the business be one in which a monopoly could ever be exercised by an individual. The agricultural class, it is true, would be the one which would be the most directly benefited by it, but the prosperity of this class, as a general rule, leads to the prosperity of all the others.

Before submitting the evidence by which I propose to show the connection between artillery firing and rains, or endeavoring to present a reasonable theory for the assumed direct relation between the two, it may be well to offer a few remarks in

regard to the commonly accepted theory of rains in general. The air, as is well understood, is the great reservoir in which is collected and stored up the water from which all storms are formed. Extending around the earth to the height of forty or fifty miles, it is capable of holding in suspension a vast amount of this fluid, which it receives from evaporation from the ocean, from lakes, rivers, pools, and from all portions of the earth's surface where any moisture is present. The water, when so evaporated, passes into the air in the form of a transparent and perfectly invisible vapor, and the warmer the air, the greater the amount of this vapor it is capable of absorbing. Rain is formed by the condensation of this vapor and its precipitation to the earth; a partial condensation first forming clouds, and rendering the vapor visible. This condensation is supposed to be caused by the cooling of the air in which it occurs, whereby the amount of vapor which it is capable of holding is lessened. Thus a warm current of air saturated with moisture meets a cooler current, and the cold of the latter condenses a portion of the aqueous vapor contained in the former, and clouds and rain are the result.*

* Rain is generally produced by the rapid union of two or more volumes of humid air differing considerably in temperature; the several portions, when mingled, being incapable of absorbing the same amount of moisture that each would retain if they had not united. If the excess is great it falls

It may be added, in connection with this theory, that the greater portion of the aqueous vapor which, by its condensation, forms our rains in North America, is produced by evaporation from the Pacific Ocean. The evaporation from the land and from the streams and lakes, though immense in its total volume, is small compared with that from the ocean, and furnishes but an insignificant portion of the water that falls as rain. This becomes apparent when we consider that as much water must come to us from the ocean as runs into the ocean by our rivers. It follows, from this fact, that there must be streams of aqueous vapor flowing above us as great, in the volume of water they carry, as are the rivers that convey back to the ocean the waters that fall to the earth. Indeed, it is reasonable to believe that these aërial streams are vastly greater than are the rivers which they replenish, for not all the waters which they carry fall to the earth. Vast quantities must pass over us without being condensed until they reach the Atlantic or Arctic Ocean or Northern Europe. There is a great and nearly constant air current moving eastward and northeastward over the United States which bears along with it this aqueous

as rain; if it is of slight amount it appears as cloud. The production of rain is the result of the law that the capacity of the air for moisture decreases in a higher ratio than the temperature. (*Silliman's Principles of Physics or Natural Philosophy*, page 656.)

vapor. All our storms, except a few from the Gulf of Mexico, originate in this current, and move eastward and northeastward along with it. Prof. M. F. Maury, who is recognized as a great scientific investigator, and whose work on the "Physical Geography of the Sea," was the result of great study and research and of a system of observations devised by him and carried out by navigators in all parts of the world, demonstrated in that work many years ago the probable existence of this current, and it has been confirmed in later years by the observations of the signal corps of the United States Army. If there were no oceans the earth would be rainless, and were it not for our vapor-bearing current from the Pacific, our country would be as barren as Sahara. I do not say that the evaporation from the land and its waters is without its effects in giving rain. When the moister current above takes on the action which causes condensation of its vapor, the surface stratum of the atmosphere is drawn more or less into the motion and adds to the result. But it is mainly from the ample stores of aqueous vapor, borne along at a high elevation by the vast moving body of air of which mention has been made, that rain many times has been and at any time could be drawn by artificial means. Nature has provided an abundance of water for refreshing our parched fields in times of drouth,

and has placed it within our reach. The sun is forever at work evaporating it for us from the Pacific, and in giving motion to the winds that bear it to us in never ending streams. It is for us to tap these streams and cause the waters to fall when the means provided by nature to produce this result fail to act at the proper times.

But dismissing for the present the subject of theories, let us proceed to facts — facts not one of which, perhaps, would be of any significance if it stood alone and unsupported by the others; but which, taken in the aggregate, furnish the strongest evidence that heavy artillery firing has an influence on the weather and tends to bring rain.

Let it be premised that, though this statement of facts is far from being a complete one, I have endeavored to make it trustworthy so far as it goes, and to that end have, in every case, referred by foot-notes or in other ways to my authority for the statements made. An important source of information on the subject treated of has been found in correspondence with officers who took part in our late war; and in cases where I have depended on such for my facts, I have given their letters in the appendix. Another important source from which facts have been derived, has been the log books of the navy, preserved in the office of the Bureau of Navigation at Washington. The log book

of a vessel of the United States Navy is a kind of journal, in which is recorded, daily, all important events that take place on board or in which the vessel takes part, together with certain other things which it is the duty of the officer of the watch to note and record at stated periods. Among the latter is a record of the weather; an entry being made in relation to the same generally every hour of the day and night. This record shows the force and direction of the wind, the appearance of the sky, whether clear or cloudy, and if there is rain, hail, sleet, fog, mist or lightning. Drizzling rain, continuous rain, and extraordinarily heavy rain are differently indicated. The temperature and the height of the barometric column are also recorded. These log books, or copies of the same, are transmitted to the Navy Department at Washington, and are there kept in the office of the Bureau of Navigation. By ascertaining from history or other records the name of any ship or gunboat that took part in any naval battle, or in any attack on a fort or on shore batteries, and looking up also the date on which such action occurred, we can, by searching for the corresponding date in the log book of such vessel, and examining the record for that date and for the days immediately preceding and following it, determine with the utmost precision what the weather was before, during and

after such engagement. The evidence which these log books give in regard to the effect of cannon firing in bringing rain, has thus almost the force which actual experiments would have if performed for that sole purpose, though they but imperfectly indicate how much powder or how many guns are required to produce that result. I have examined many of these books, and, as will be seen by the references, have found in them some of my most important facts. Probably many more could be obtained from the same source, as they are a perfect mine of information on this subject; but though furnished, through the kindness and courtesy of the Bureau, with every facility in the examination of these books, but a limited time could be given to the work, and it has been necessarily hasty and far from complete. If the facts, however, which I shall present, are insufficient to convince, it would be in vain to hope to do so with a greater number.

I shall go back to our war with Mexico for the first instance which I shall mention of rain as a direct result of a battle. This occurred at

THE BATTLE OF BUENA VISTA, MEXICO,

fought 22nd and 23rd of February, 1847. This was in the dry season in that country; there had been no rain for several months before the battle,

and there was none for several months after. Three showers, however, followed the first day's engagement,[1] two of which are specially remarkable. On the 23rd, about one or two hours after the severe cannonading that took place between 8 and 10 A. M., there was a most violent rainfall for some ten or fifteen minutes. Again, in the afternoon, at about the same interval, after another spell of heavy cannonading, another violent shower of rain fell. The fact before stated, that no rain had fallen for months before the battle, and that none fell for months after at that place, is almost proof positive, not only that the cannonading caused the rain, but that cannonading will bring rain at a time when the atmospheric conditions are apparently in the highest degree unfavorable to the production of that phenomenon through the ordinary operations of nature.

THE BATTLE OF PALO ALTO, MEXICO,

8th May, 1846, also fought in the dry season, was also followed by rain,[2] but the particulars cannot be given.

THE BATTLE OR SIEGE OF MONTEREY, MEXICO,

was fought September 21 to 23, 1846, which, like the dates before mentioned, was in the dry season. The morning of the 21st was bright and beautiful,

[1] See appended letters, Nos. 7 and 27. [2] See No. 30 of Appendix.

but "soon after the storming of the two forts, Federacion and Soldado, a violent storm came up," and to its "unbroken peltings" General Worth and the 2nd Division were exposed during the night.[3] A similar phenomenon occurred also on the 23rd. The morning was bright and fair, with no indications of rain; during the day there was heavy cannonading, and "the evening and night closed in with heavy rain."[4]

THE BATTLE OF CONTRERAS, MEXICO,

was fought August 19, 1847, and at a season when rains were very unfrequent. At Puebla during the months of June and July, and perhaps the beginning of August, there had been heavy falls of rain *every afternoon*, the skies clearing before sunset, and the atmosphere being remarkably clear until the next afternoon. Our army commenced its march from Puebla on the 7th, and from that time until the 16th the days were generally, if not always, clear, bright, and beautiful.[5] On the 16th the movement commenced at Chalco, and on the next two days there was some rain, but it was not heavy. The morning of the 19th was bright and clear,[6] and such was also the afternoon[7] at the usual hour for rains.

But on this day "the battle raged furiously, and

[3] See No. 27 and No. 30. [4] See No. 28. [5] See No. 26. [6] See No. 28.
[7] See No. 26 of Appendix.

for more than three hours the entire force was under a heavy fire." "Night at length put an end to the conflict;" and "a cold rain soon afterwards began to fall in torrents."[8]

THE BATTLE OF CHURUBUSCO

was fought the next day, which was bright and clear. The day after it rained heavily.[9]

THE BATTLE OF MOLINO DEL REY, MEXICO,

fought September 8, 1847, was also followed in the afternoon and evening by a hard rain.[10]

THE BATTLE OF CHEPULTEPEC, MEXICO,

fought September 13, 1847, was also followed by rain; and whatever doubt may be entertained as to the significance of the facts of rain following the battles of Contreras and Churubusco, on account of their nearness to the wet season, it cannot be doubted that at this time the dry season had fully set in. The day of the battle was followed by a dark and cloudy night,[11] with rain in the early morning of the day following. The Mexican historian says: "The morning of the 14th was as gloomy and sad as the destiny of the Republic. There was a mist so thick that objects could not be seen at a few steps distance. Soon after, a light shower began to fall which soaked the soldiers,"[12] etc. Later in the morning the weather became clear.

[9] See No. 26 of Appendix. [8] [10] See No. 27. [11] See No. 27. [12] See No. 30.

During the late war of the rebellion, the occurrence of the phenomenon under discussion was frequent.

THE BATTLE OF BIG BETHEL

may be mentioned as an early instance. This battle, fought in Eastern Virginia on the 10th of June, 1861, was soon followed by a copious rain.[13]

Incessant rains attended General McClellan's

CAMPAIGN IN WESTERN VIRGINIA,

in July, 1861. It has been published that his troops "had four separate engagements on four days, and before the close of each, violent rains fell."[14] The

BATTLE OF RICH MOUNTAIN,

fought July 10, was one of these, and was followed by one or two rainy days.[15]

The following engagements, which took place in that section of the country later in the same year, were also each followed quickly by rain, viz.:

BATTLE OF CARNIFAX FERRY,[16]

fought August 10, 1861.

BATTLE OF CHEAT MOUNTAIN,[17]

fought 13th and 14th September, 1861.

BATTLE OF GREEN BRIER,[18]

fought October 3, 1861.

13 See No. 39.
14 See page 79.
15 See No. 5.
16 See No. 17.
17, 18 See No. 38.

BATTLE OF ALLEGHANY SUMMIT,[19]

fought December 12, 1861.

None of these are classed as great battles, but the firing was, apparently, sufficient to bring rain. At the first great battle of the war the resulting phenomenon was similar, but more intensified. This, the

FIRST BATTLE OF BULL RUN,

was fought on the 21st of July, 1861. The day of the battle was bright and clear all through, but the next day was one of drenching rain. The storm commenced about six o'clock in the morning and continued all day and through the following night; the rain, during the afternoon and night especially, falling in torrents.[20]

As early in the war as the

SIEGE OF LEXINGTON, MISSOURI,

which ended on the 20th of September, 1861, in the surrender of Colonel Mulligan to the Confederates, the fact that heavy artillery firing was usually followed by rain, had already been noticed in the West. On the 17th the beleaguered garrison were cut off from the river, and thus deprived of water; but to encourage the soldiers to hold out as long as possible for the arrival of the expected reinforcements, it was represented to them, by their

[19] See No. 38. [20] See Nos. 1, 3, 20 and 26 of Appendix.

officers, that the cannonading would surely bring rain to quench their thirst. And this prediction was fulfilled; though, unfortunately, they had no way to catch the water which their firing had drawn from the skies, except by spreading their blankets to the shower, and then wringing them out.[21]

In the South, as well as in the East and West, rain followed heavy cannonading. An

ENGAGEMENT NEAR FORT PICKENS, FLORIDA,

was an early instance. Flag Officer William W. McKean, commanding Gulf Blockading Squadron, in a report to the Secretary of the Navy dated November 25, 1861, thus mentions the circumstance. He says: "Sir—I have the honor to inform you that on the 22nd instant, a combined attack was made upon the rebels at this place by Colonel Brown, of Fort Pickens, and the United States ships Niagara and Richmond under my command. * * * At ten o'clock, at the firing of the first gun from the Fort (the signal agreed upon), the Niagara stood in, followed by the Richmond, and both ships came to anchor. * * * We immediately opened fire. * * * At six P. M. a sudden squall came up from the northward and westward, the wind blowing very fresh, with heavy rain," etc.[22]

[21] See No. 4. See also Greeley's "History of the American Conflict," Vol. I., page 588.

[22] See Documents accompanying Report of Secretary of Navy, of December 1, 1862.

In the middle portions of the country also, as well as in the East, West and South, the phenomenon referred to was, early in the war, exhibited. The

BATTLE OF LOGAN'S CROSS ROADS

is an instance. The author of the "American Conflict," in speaking of the pursuit of the Confederates after this battle, says: "It rained as usual,"[23] a remark which is understood to recognize a truth which it is the object of this treatise to bring forward — and which receives still more pointed notice on a subsequent page of that work.[24]

THE BATTLE OF FORT DONELSON,

which all will remember as one of the first great victories of the war for the Union, affords another instance of the kind under consideration. The siege commenced on the 13th of February, 1862, which was a clear, bright day, as was also the next. The artillery firing commenced on the 14th, by a desperate fight of an hour's duration between Commodore Foote's gunboats and the batteries of the fort; the gunboats finally retiring, badly crippled. The next day the battle was renewed by the land forces, and ended in a storm of snow, which in turn was followed by one of rain.[25] The weather this day changed to cold — a change which, it is

[23] Vol. II., page 43. [24] Vol. II., page 392. [25] See No. 3.

presumed, would have occurred if there had been no battle; but the effect of the cold was to turn in part into snow and sleet the storm which the cannonading brought, and which would otherwise have probably been one wholly of rain.

THE BATTLE OF PEA RIDGE, ARKANSAS,

fought March 7 and 8, 1862, was followed on the morning of the 9th by a hard rain.[26]

All the important operations of the expedition which was sent under General Burnside and Commodore (afterwards Rear Admiral) L. M. Goldsborough against the Confederate strongholds in North Carolina, were each quickly followed by rain. The first of these was the attack upon and capture of

ROANOKE ISLAND,

on the 7th and 8th of February, 1862. Commodore Goldsborough, in his official report, in speaking of the weather at daylight in the morning of the 7th, says: "The sky gave evident signs of a clear day." In the course of the forenoon his gunboats commenced an attack on the rebel batteries and gunboats, which was continued through the day. In the night it commenced to rain,[27] and the next day was rainy throughout. On the second day of the fight, the engagement was renewed by the fleet,

[26] See No. 34 of Appendix.

[27] [28] Log of the "Stars and Stripes." See also Am. Conflict, Vol II., p. 75, and No. 35 of Appendix.

while the land forces assaulted and carried the works in the rear. The rain which accompanied and followed this day's action, continued until noon of the day following.[28]

The next important movement of this expedition was against

NEWBERN, NORTH CAROLINA.

The city was taken on the 14th of March, 1862, but there was much heavy firing on the 13th by the gunboats, and in the night there was a pouring rain.[29] No rain fell on the day of the assault and capture of the enemy's works, but the day after was very rainy.[30]

The next and last important operation of the expedition above referred to was the

CAPTURE OF FORT MACON.

Fire was opened on this work from General Burnside's siege guns on the 25th of April, 1862, at about six o'clock in the morning, and was continued until late in the afternoon; four of Commodore Goldsborough's vessels also taking part in the action. The sky that morning was clear, and so remained until about six o'clock in the afternoon. At that hour it became overspread with clouds, and the next afternoon it rained,[31] the rain falling heavily for three hours.

[29] "Am. Conflict," Vol. II. p. 77. [30] Log of the U. S. Steamer "Delaware."
[31] Log of U. S. Steamer "Daylight."

THE NAVAL ACTION IN HAMPTON ROADS,

in which the U. S. Ships Congress and Cumberland were destroyed by the Merrimack and other Confederate vessels, furnishes another instance of rain following the discharge of artillery. The fight took place on the 8th of March, 1862, a clear, cool day. The next day—the one on which the contest happened between the Merrimack and Monitor—there were four hours of drizzling rain.[32]

On the Mississippi River, scarcely an action of any moment occurred that was not followed immediately by rain. The engagement which resulted in

THE CAPTURE OF NEW MADRID, MISSOURI,

was a marked instance. The fight took place on the 13th of March, 1862; a heavy cannonade was kept up from both sides through the day, and a violent thunder storm raged through most of the night.[33]

AT ISLAND NO. TEN,

several instances of the kind occurred. The first was at the general attack that was made on the batteries of the island by Commodore Foote's flotilla. This attack was made on the 17th of March, 1862; and during the next day, also, the mortar vessels continued to throw shells into the rebel works.

[32] Log of the U. S. Steamer "Roanoke." See also No. 39.
[33] Am. Conflict, Vol. II., p. 55.

The weather on the first day was clear, and on the second it was the same until six P. M. At that hour the sky became overcast, and thunder showers followed in the latter part of the night.[34]

ANOTHER INSTANCE OF A SIMILAR KIND OCCURRED AT THE SAME PLACE,

a short time after. Under date of April 3, 1862, eight to twelve A. M., the Log of the "Benton" says: "Clear and calm and very warm. The Benton, Cincinnati and Carondelet have taken position along the Missouri shore and opened fire on the floating battery and Island. The mortars are also actively engaged." The weather which followed this engagement is thus stated, under date of April 4, From four to eight A. M., "Clear weather until six o'clock, then clouded up and threatened rain." From eight to twelve, "Fresh breeze from E. S. E., attended with much rain." From twelve to four P. M., "Passing showers from southward and eastward until two o'clock; two o'clock till four clear, with moderate breezes from S. W. S."

This rain, which took place on the fourth, we may suppose to have been brought on by the action of the third. But there was also an

ACTION ON THE MORNING OF THE FOURTH,

which, apparently, produced another rain, and one

[34] Log of the "Benton."

more violent than the first. The nature of this engagement is thus explained in a dispatch from Flag Officer Foote to the Secretary of the Navy, dated April 4, 1862. He says: "This morning the Benton, Cincinnati and Pittsburg, with three mortar boats, opened and continued for more than an hour a fire on the rebels' floating battery at Island No. 10. * * * The shells were thrown from the flotilla into different forts of the island, and into the rebel batteries lining the Tennessee shore." Continuing to quote from the Log Book of the Benton for April 4, 1862, the weather a few hours after this action, and after the other shower had fully cleared away, is thus described: From four to six P. M., "Wind South;" from six to eight P. M., "Fresh breeze from S. and cloudy;" from eight to twelve P. M., "Variable winds and heavy showers of rain, accompanied with very vivid and constant lightning and some thunder." It was in this thunder storm that the gunboat Carondelet ran the rebel batteries.

There was still

ANOTHER RAIN FOLLOWING HEAVY CANNONADING AT ISLAND NO. TEN.

The firing, as referred to in one of the dispatches of Commodore Foote, dated April 8, 1862, occurred on the seventh. General Pope is spoken of as

having crossed the river that day under a heavy fire, and reference is made to the reduction of a fort by two gunboats. The rain occurred on the morning of the eighth, and is mentioned in another dispatch of Commodore Foote of that date as a heavy thunder storm.[35]

As the Island surrendered on the eighth, I have no further thunder storms to record as following cannonading at that point.

At the

BOMBARDMENT OF FORTS JACKSON AND ST. PHILIP,

on the Mississippi River, below New Orleans, commencing April 18, 1862, two days of rather slow firing, in dry weather, by Farragut's fleet, was followed, on the morning of the third, by some four hours of rain.[36]

THE GRAND ATTACK UPON AND PASSAGE OF THE FORTS

and destruction of the rebel fleet on the twenty-fourth, was followed by a terrific thunder storm, lasting about five hours. The attack commenced between three or four o'clock in the morning, under a sky which remained cloudless until four P. M.; and the rain commenced between eleven and twelve A. M. next day.[37] This furious storm was raging when the fleet reached the city of New Orleans.

[35] See Documents accompanying Report of the Secretary of the Navy of December 1, 1862.

[36, 37] Log of the Hartford. See also Am. Conflict, Vol. II., p. 94. Also appended letter No. 41.

A thunder storm also followed the

BOMBARDMENT AND PASSAGE OF THE VICKSBURG BATTERIES

by some vessels of Farragut's fleet and of the mortar flotilla, on the morning of June 28, 1862. The attack was made at three o'clock in the morning, with some thirteen or fourteen vessels, and while they were steaming past the city the firing was rapid and heavy. The weather at the time was clear, with the exception of some detached clouds, and so remained until midnight of that day. Through the remainder of the night clouds and lightning were seen, and the morning brought several hours of weather "squally, with rain and heavy thunder and lightning."[38]

Again, on the morning of June 30,

THE MORTAR VESSELS ENGAGED THE VICKSBURG BATTERIES.

The next morning there was a terrific thunder storm, lasting about two hours. The amount and intensity of the lightning, and the violence of the rain in this storm, were extraordinary.[39]

THE NAVAL ENGAGEMENT NEAR VICKSBURG,

on the morning of July 15, 1862, was also followed by a storm. An expedition had started up the

[38, 39] Log Book of the U. S. Steamship Hartford.

Yazoo River, that morning, to destroy the rebel ram "Arkansas," when it met that vessel coming down. A severe fight ensued, in which two of our vessels were disabled; after which the Arkansas escaped into the Mississippi, and took refuge under the Vicksburg batteries, from which unsuccessful attempts were made to cut her out, the last being made in the evening. The weather was clear at the time this fighting commenced, as it had been for nearly two weeks previous; but between four and six in the afternoon there was a shower; and about midnight a heavy rain commenced which lasted, with varying intensity, until four o'clock in the afternoon of the following day.[40] After this there was another spell of dry weather, broken by

ANOTHER ENGAGEMENT AT VICKSBURG,

occurring on the 22nd of July, 1862. On this day the "Benton," "Louisville" and "Cincinnati" attacked the upper batteries, while the "Essex" and ram "Queen of the West" went down and attacked the rebel ram "Arkansas" in her place at the levee. The action commenced at 4.30 A. M., the weather being at the time clear and calm. Soon after the action a light variable wind sprang up. In the afternoon the sky became overclouded, with light west wind. From four to six P. M., clear

[40] Log of the "Benton."

and calm again. In the evening it again became overcast, with light wind first from south then from west, and after midnight variable. From noon to four P. M. fresh southwest wind with rain.[41]

Tremendous rains fell during the night of each day of

THE BATTLE OF PITTSBURG LANDING, OR SHILOH,

Tennessee, fought on the 6th and 7th of April, 1862. The morning of the sixth was clear and beautiful, with no indications of a storm, but the day's terrific battle was followed by a night of drenching rain.[42] The battle of the next day was also succeeded in the night by a fearful storm, which, in this case, consisted of rain, hail and sleet. "An impressed New Yorker," in writing of the retreat of the Confederate army on this terrible night, says: "And to add to the horrors of the scene, the elements of heaven marshalled their forces — a fitting accompaniment of the tempest of human desolation and passion which was raging. A cold, drizzling rain commenced about nightfall, and soon came harder and faster, then turned to pitiless, blinding hail. This storm raged with unrelenting violence for three hours. I passed long wagon trains filled with wounded and dying soldiers, without even a blanket to shield them from the driving

[41] Log of the "Benton." [42] See appended Letters, Nos. 3, 14, 16 and 28.

sleet and hail, which fell in stones as large as partridge eggs until it lay on the ground two inches deep."[49]

In the list of military conflicts followed by rain, is also to be placed the

BATTLE OF BULL PASTURE MOUNTAIN, OR M'DOWELL.

This battle was fought in Western Virginia, on the 8th of May, 1862; and the circumstances connected with the rain were such as to aid in confirming an officer, who was present, in his belief that rain was a direct result of battle.[50]

In this list is also to be placed General Banks'

BATTLE OF WINCHESTER, VIRGINIA.

Banks' retreat from the Shenandoah Valley was made on the 24th and 25th of May, 1862; and the battle occurred on the morning of the 25th, which was a dry, hot day. The weather which followed is thus referred to in history, in connection with the movement which was immediately made by General Fremont, with a view to intercept Jackson on his return from his pursuit of Banks; viz., "Through constant rains and over mountain roads that could be made barely passable, he crossed the Alleghanies and descended into the Valley."[51]

[49] See note on page 60, Vol. II., of "American Conflict."
[50] See No. 38.
[51] American Conflict, Vol. II., p. 137.

AFTER THE BATTLE OF CROSS KEYS,

fought in the Shenandoah Valley between Generals Fremont and Jackson, on the 8th day of June, 1862, it again rained in that section of the country,[52] and on the night of the ninth the rain had extended to the southeastern part of the State.[53] The battle of Port Republic was fought by the same forces on the ninth, and again on the night of the tenth rain appeared in Southeastern Virginia."[54]

The history of

GENERAL M'CLELLAN'S CAMPAIGN ON THE PENINSULA,

from the investment of Yorktown to the sanguinary battle of Malvern Hill, presents a continued succession of battles and rains. His first advance was commenced on the fourth of April, 1862, and was stopped on the night of the sixth, by the fire of rebel batteries; and the cannonading that then and soon after ensued was followed on the seventh, eighth and ninth, at the point of observation of the U. S. Steamer Wachusett, with more or less rain each day. In tracing the subsequent rains, in connection with the history of the time, great assistance is rendered by some extracts which have been kindly furnished from the journal of Major General Heintzelman, who commanded an army corps in the campaign.

[52] See Appended Letters No. 5 and 38. [53], [54] See Document No. 20.

Commencing with the operations immediately preceding the

CAPTURE OF YORKTOWN,

we find from the journal referred to, that on the second of May, 1862, "some five hundred shot and shell were fired by the rebels," also that on the night of the third "the rebels were very busy until after midnight firing." This firing, however, brought no rain, though on the third it "threatened rain."[55] On the night of the third they abandoned their works at Yorktown, and being pursued, the next day there ensued, at

FORT MAGRUDER,

in front of Williamsburg, a sharp cannonade.[56] During the following night a heavy rain set in.[57]

The next day was fought the

BATTLE OF WILLIAMSBURG.

It rained through the day and into the night following.[58]

THE FIGHTING ON THE CHICKAHOMINY,

between the advance of the army and the rebels, commenced on the twenty-fourth of May. On the twenty-seventh we read of "pouring rains."[59] At this date occurred the

[55] See No. 20 of Appendix.
[56] American Conflict, Vol. II., p. 122.
[57] See No. 20 of Appendix.
[58] See No. 20.
[59] American Conflict, Vol. II., p. 141.

BATTLE OF HANOVER COURT HOUSE,

and on the thirtieth there was a heavy thunder storm, the rain falling in torrents.[60]

On the afternoon of May 31, and morning of June 1, was fought the great

BATTLE OF FAIR OAKS, OR SEVEN PINES.

On the morning of the second it began to rain; during the night of that day it rained heavily; and on the night of the third and morning of the fourth the very flood-gates of heaven seemed to be opened. By the fearful rains which followed this battle, the surrounding country was flooded, and movements on the part of either army rendered, for a time, almost impossible.[61]

The weather after this rain remained unsettled for some days — but without attempting to show a connection between this fact and the firing that occurred in the meantime between the two armies still facing each other on the Chickahominy, I will pass over a period of about two weeks to notice some

GUNBOAT FIRING ON JAMES RIVER.

In the journal of Major General Heintzelman it is recorded, under date of June 17, 1862, "The gunboats were firing nearly two hours to-day;" and

60 See No. 20.

61 See No. 20. Also Gen. McClellan's official dispatches.

under date of the eighteenth, "Since dark a heavy wind and rain."[62]

ARTILLERY FIRING IN FRONT OF HOOKER.

Gen. Heintzelman, also, in his journal from which these extracts are given, speaks of musketry and artillery firing along Hooker's front on June 21, and of rain on the twenty-second and twenty-third, though neither the firing nor the rains appear to have been of much consequence.[63]

MORE ARTILLERY FIRING.

Under date of the twenty-fourth it is recorded: "At dawn heavy musketry commenced, soon followed by artillery;" and, "Had another heavy rain a little before night."[64]

Let me pause here a moment to remark, what indeed must be obvious, that neither artillery firing nor any means within the resources of nature, can extract an unlimited amount of water from a limited amount of air within a limited time. In the month of June up to and including the date last given, vast quantities of rain had fallen on ground occupied by the contending armies. The presence of so much water in the atmosphere immediately over the scene of these conflicts can only be accounted for by the existence of vapor-bearing cur-

62 63 64 See No. 20 of Appendix.

rents from the ocean, to which I have already alluded and of which I shall say more hereafter.

The famous

SEVEN DAYS' FIGHT

commenced in the afternoon of the twenty-sixth of June, 1862, with the battle of Mechanicsville,[65] though there was an affair on the preceding day that involved a loss of some five hundred men in killed, wounded and missing. On the twenty-seventh was fought the sanguinary

BATTLE OF GAINES' MILL,

and on the twenty-eighth there was considerable artillery firing, but no regular battle. The twenty-seventh was a bright clear day, as was also the twenty-eighth, except that on the morning of the twenty-eighth there was, for a time, an appearance as of coming rain; but on the night of the twenty-eighth and morning of the twenty-ninth, it rained heavily.[66] This rain appears to have been confined to a comparatively limited extent of country.

On the twenty-ninth was fought

THE BATTLE OF SAVAGE'S STATION.

A heavy thunder storm followed in the night, passing over a part of the country east of and near the battle-field, though perhaps not reaching the

[65] For the authority for this division, see Greeley's American Conflict, Vol. II., page 167.

[66] See No. 26, of Appendix.

field itself. At a point on the Pamunkey River between White House and the York River, the storm lasted with varying severity for from five to six hours, during two of which the rain fell in torrents.[67]

Next day was fought the battle of Glendale, and on the next day after (July 1, 1862,) the fearful

BATTLE OF MALVERN HILL.

A terrific storm followed, commencing before daylight the next morning,[68] and continuing through the day, and during most of the following night; and accompanied, during a portion of its progress, with hail,[69] as well as with thunder and lightning, and torrents of rain. This storm appears to have extended over all the surrounding country.[70]

This day of storm (July 2, 1862,) was the last of the historic seven of battle and retreat; and after the battle of Malvern Hill there is no account of further cannonading until the morning of the 3rd, when, at half-past 10 A. M., the rebels commenced

THROWING SHELLS INTO THE CAMP,

at Harrison's Bar, but were soon driven off by the

[67] See Log of U. S. Steamer Sebago on Pamunkey River.
[68] See Nos. 1, 20, 26 and 41.
[69] Log of Steamer Sebago in Hampton Roads.
[70] See Log of Steamer Sebago in Hampton Roads, and of the Galena on James River

fire of the batteries and of the gunboats. In the evening and night of that day it again rained.[71]

While the army remained inactive at Harrison's Bar, after the above battles, there occurred an instance of

GUNBOAT FIRING ON JAMES RIVER,

followed by rain. In the journal to which reference has been made, is written, under date of July 15, 1862, "there has been some gunboat firing down the river." Also, under same date, "at dark a heavy thunder storm."[72]

Having shown that all the great battles of Gen. McClellan's campaign against Richmond were followed by great rains, and most of the minor collisions by rains more than proportionately heavy, I will next show that rain also followed all the principal engagements of the army of Virginia, commanded by Maj. Gen. Pope, which soon after the date last above referred to, advanced against the enemy in Virginia, by way of Culpepper Court House, on the Orange and Alexandria Railroad. The first engagement of this campaign was

THE BATTLE OF CEDAR MOUNTAIN,

fought August 9, 1862, between Gen. Banks' corps and a superior force under Stonewall Jackson.

[71] Log of the U. S. Steamer Galena on James River.
[72] See No. 20 of Appendix.

Rain followed as usual;[73] but as the amount of artillery firing in this engagement was small, so likewise was the amount of rain which it apparently produced, a certain proportion being observed between the two as compared with some other battles.[74]

The next engagement of any consequence was at the Rappahannock River, on Gen. Pope's retreat, and consisted principally in

HEAVY ARTILLERY FIRING AT KELLEY'S FORD AND RAPPAHANNOCK STATION,

on the 20th, 21st, and 22nd August, it being particularly heavy on the 21st and 22nd. In the night of the 22nd a tremendous rain set in, which drowned all the fords, and carried away all the bridges at the front, and rendered impossible an aggressive movement which Gen. Pope had meditated.[75] There was also a shower in the afternoon.

The next heavy artillery firing was on the night of the 26th, followed by still more on the 27th. During this day, different portions of Gen. Pope's forces were engaged with the enemy, the most serious encounter being the

FIGHT AT BRISTOW STATION,

in which there was a loss of some three hundred men on each side. This was followed, at about 9

[73] See Nos. 11 and 38, Appendix.
[74] See No. 38.
[75] Am. Conflict, Vol. II., p. 178.

o'clock in the evening, by a little rain, and on the day following by a heavy shower.[76]

We come next to the

SECOND BATTLE OF BULL RUN,

fought on the 29th and 30th of August, 1862. The battle commenced in the morning of the 29th, and was followed on the morning of the 31st and afternoon of the next day by heavy rains.[77]

The last of this series of engagements was the

BATTLE OF CHANTILLY,

fought September 1, 1862. It was commenced at 5 P. M., by two divisions under Gen. Reno, which attacked a superior force under Stonewall Jackson, and were repulsed. Afterwards, Gen. Kearney "advanced and renewed the action in the midst of "a thunder-storm so violent that ammunition could "with great difficulty be kept serviceable, while "the roar of cannon was utterly unheard at Centre-"ville, barely three miles distant."[78] To the cannonading on the last day of the preceding battle this storm should, perhaps, in a great measure be attributed.

At the

GREAT BATTLE OF ANTIETAM,

in Maryland, the phenomenon of rain following the

[76] See Nos. 20 and 38, Appendix. [77] See Nos. 1, 5, 11, 20, 22, and 38.
[78] Am. Conflict, Vol. II. p. 188. See also Nos. 11 and 20.

discharge of artillery was again exhibited. The battle was fought on the 17th of September, 1862; the rain was on the afternoon of the 18th, and consisted of a sudden and heavy shower.[79]

THE BATTLE OF PERRYVILLE, OR CHAPLIN'S CREEK, KENTUCKY,

fought between the armies of Generals Buell and Bragg, on the 8th of October, 1862, furnishes a remarkable instance of rain following artillery firing, during a time in which the state of the atmosphere would be considered by some as exceedingly unfavorable to the production of that phenomenon. A great drouth was prevailing in the State at that time, causing severe privation and suffering in the army both to men and animals;[80] but the battle seems to have brought a change, for a heavy rain followed.[81] This fact is important, as it shows that a state of drouth by no means proves that there are not ample supplies of aqueous vapor somewhere within reach of the noise and concussion produced by the discharge of ordnance, and which can be drawn on for rain at any time.

THE BATTLE OF PRAIRIE GROVE, ARK.,

fought Dec. 7, 1862, furnishes a somewhat similar instance. We read in history that the weather

[79] See Appended Letters Nos. 1, 2, 22, and 33.
[80] Am. Conflict, Vol. II. page 218. [81] See No. 8.

at the time was clear and dry;[82] and yet we learn that on the day after the battle it rained.[83]

The firing at the

CAPTURE OF VAN BUREN, ARK.,

was also followed by rain.[84]

A heavy storm followed the

ATTACK ON THE DEFENCES ON THE NORTH SIDE OF VICKSBURG,

by the formidable expedition that was sent against that place in December, 1862, under General Sherman and Admiral Porter. From the commencement of the debarkation of the troops, on the morning of the 26th, until the battle, the weather was good, being for the most part "clear and pleasant." There was some preliminary fighting on the 28th, and on the 29th the grand assault was made, the battle commencing early in the day. Between four and six in the evening rain commenced to fall, and from eight to midnight it came down in torrents. This rain continued until about eight o'clock the next morning.[85]

THE BATTLE OF MURFREESBORO, OR STONE RIVER,

is one of the many great battles that have commenced in fine weather and ended in pouring rain.

[82] American Conflict. Vol. II. page 87.
[83] See Nos. 4 and 34, Appendix.
[84] See Appendix No. 4.
[85] Log of the Benton. See also Am. Conflict, Vol. II. p. 291.

This battle was fought on the 31st of December, 1862, and 1st and 2nd of January, 1863. The first day of the battle was bright[86] and clear, but on the last a heavy storm set in, which continued through the night and a great part of the following day.[87]

We have seen that nearly all[88] the battles, both great and small, of the Eastern armies, up to and including that of Antietam, were followed by rain. After Antietam, the next great battle fought by the Army of the Potomac was the

BATTLE OF FREDERICKSBURG, VA.,

fought Dec. 13, 1862, and the same is true of this as of the others. The day of the battle, with the exception that there was a fog in the morning, was bright and sunny,[89] but a heavy storm of rain followed, commencing on the night of the 15th, while the army was re-crossing the Rappahannock.[90]

Next in order of the battles of the Army of the Potomac was the

BATTLE OF CHANCELLORSVILLE,

fought May 2nd, 3rd and 4th, 1863, and at this, too, the same phenomenon was exhibited. On the third day after the commencement of the movement, in

86 Greeley's American Conflict, Vol. II. p. 279.

87 See Letters No. 8, 14, 16, 28 and 29. Also, Am. Conflict, Vol. II. p. 280.

88 The battle of South Mountain, Md., fought Sept. 14, 1862, seems to have been the most marked exception to the general rule.

89 Am. Conflict, Vol. II. p. 344.

90 See Appendix Nos. 1, 2, 13, 22, 31 and 38.

the midst of a rapid cannonade, there came on a fearful thunder storm, and for a time the soldiers fighting in the woods were unable to distinguish the "artillery of heaven" from that of earth.[91] In the afternoon and night of May 5, the storm was so violent as to cause a great flood in the Rappahannock, sweeping away some of the pontoons forming the bridges on which the army was that night recrossing the river, thus delaying the movement and threatening for a time to lead to serious consequences.[92]

It also rained[93] immediately after the

BATTLE OF BEVERLEY FORD, VIRGINIA,

fought June 9, 1863. This was a sharp fight, lasting about half a day, the forces engaged on the Union side consisting, besides cavalry, of two brigades of infantry and two batteries of artillery detached from the Army of the Potomac.

Following Chancellorsville, the next great encounter of the Army of the Potomac with that of General Lee was

THE BATTLE OF GETTYSBURG, PA.,

fought July 1, 2 and 3, 1863; and this, too, was followed by a rain, and one that would compare, in the amount of water that fell, with the rains which had followed any of the previous battles. The battle was

[91] See Appendix No. 24.
[92] See Appendix Nos. 1, 2, 12, 22, 25 and 38.
[93] See Appendix No. 11.

fought in clear weather, except that during the first day's fight there was a slight shower, and again another in the evening of that day, but they were both so unimportant as to have been generally unnoticed. The great rain commenced on the night of the 3rd, about six hours after the firing had ceased; and through the 4th, and also part of the 5th, it rained furiously. The storm must also have extended a great distance southwestward, as it caused a flood in the Potomac which lasted several days, stopping in the meantime the retreat of the rebel army.[94] At Westminster, about thirty miles in a southeasterly direction from the battle-field, the rain seems to have commenced about eighteen hours later than at the latter place; and it continued to rain there heavily through the second night after the battle.[95]

After the return of the Confederate army to Virginia, pursued by the Army of the Potomac, rain still continued to follow their battles. The

ENGAGEMENT NEAR BRISTOW STATION

may be mentioned as an instance. A former engagement at that place has already been referred to. The second was a fight which occurred on the 14th of October, 1863, between portions of the respective armies, in which six pieces of artillery were captured from the Confederates, while the loss to the Union

[94] See Nos. 2, 3, 5, 11, 20, 24, 26, 31 and 38 of Appendix.
[95] See No. 12 of Appendix.

side in killed and wounded was about 200 men. This, on the 16th, was followed by a heavy rain, rendering the creeks unfordable, and seriously interfering with the plans of the Union commander.[96]

The affair of

MINE RUN, VA.,

is another instance. This movement took place in November, 1863. The heaviest fighting was on the 27th, being such as to entail a loss on either side of from 300 to 500 men in killed and wounded. The next day at evening there was a pelting rain.[97]

The

DESTRUCTION OF THE REBEL STEAMER, NASHVILLE,

near Fort McAllister, Ga., by the U. S. vessels, Montauk, Seneca, Wissahicon, and Dawn, furnishes a good instance of heavy rain apparently brought on by an action in which only a moderate number of guns were employed. On one side were the Union vessels named, which fired deliberately, and on the other the Nashville and the fort. The engagement took place on the 28th of February, 1863, and lasted two hours and three-quarters. The following is from the log of the steamer Montauk:

February 28, from 12 to 4 A. M., "Light, variable airs and clear weather." * * * "At 7.07 opened fire on the Nashville, aground in 7 mile reach."

[96] Am. Conflict, Vol. II. p. 396. [97] American Conflict, Vol. II. p. 401.

From 12 to 4 P. M., "Light easterly winds and partially overcast."

From 6 to 8 P. M., "Moderate wind from S. W.; cloudy and rainy."

From 8 to 12 midnight, "Light baffling winds and much rain."

February 29, from 12 midnight to 2 A. M., "incessant rain."

March 1, 8 to 12 A. M., "Pleasant."

THE BATTLE OF CARNEY'S BRIDGE, LA.,

fought January 14, 1863, and in which four gunboats and four or five regiments of troops were engaged, was followed in the night by a furious rain, which commenced about 1 A. M., and continued with varying severity until 8. There had been some rain the night before, and the morning of the action was cloudy.[98]

At

PORT HUDSON,

on the Mississippi River, a number of naval and military engagements occurred that were each followed by rain. The first that will be mentioned was the

PASSAGE OF THE BATTERIES

by Admiral Farragut, with a number of vessels of his fleet, on the night of the 14th of March, 1863. Fire was opened at about half-past 11, and "soon

[98] Log of the "Calhoun."

"the earth trembled to the roar of all the rebel "batteries."* A vast bonfire was kindled, by the light of which the rebel gunners poured their fire into the passing vessels, while the latter replied with broadside after broadside, as each came within range. This commotion of earth and air was not without its effects. The weather of the day preceding and morning following the action showed blue sky, with detached clouds; and at the commencement of the fight there was a light breeze blowing from the northward. Soon after the battle commenced, however, it became calm, and so continued until about 9 o'clock the next evening. But before this time the storm had commenced—coming up between 12 and 1 in the afternoon. At 1 it rained, and at 2 it poured. From this time until 10 o'clock at night it rained incessantly, the rain, until 8, falling in torrents.[99]

The

ASSAULT ON PORT HUDSON,

by Gen. Banks, May 27, 1863, was also followed by heavy rain. The sky, on the morning of that day, was cloudless, but on the 29th it rained heavily and continuously for four hours.[100]

Again, on the 9th of June, 1863, during a spell

* Am. Conflict, Vol. II. p. 329.

99 Log of the U. S. Steam Sloop "Hartford."

100 Log of the Hartford. See also No. 41 of Appendix.

of clear and pleasant weather, it is recorded in the log book of the "Hartford," that heavy firing was heard at Port Hudson. The next morning the sky became overcast, but the clouds afterwards dispersed, and from 4 to 8 A. M. it was again "clear and pleasant." But, on the morning of this day (the 10th) an attempt was made by Gen. Banks, under a

HEAVY FIRE OF ARTILLERY,

to establish his lines within attacking distance of the enemy's works.[1] The firing was heavier than that of the day before, and within less than twenty-four hours it was followed by floods of rain. The log of the Hartford for the 11th says: "About 3.20 A. M., squall of wind; let go the port anchor; rain came up from northward, and continued to blow 15 minutes, and rain until 4 A. M." (the end of the watch). The officer of the next watch (from 4 to 8 A. M.) enters in the log the following: "Heavy firing at Port Hudson during the watch, also heavy rain."

This latter

FIRING AT PORT HUDSON

was followed, after a cessation of the above storm for some hours during the middle of the day, by a violent shower in the latter part of the afternoon.[2]

Again at the

[1] Am. Conflict, Vol. II. p. 335. [2] Log of the Hartford.

SECOND GENERAL ASSAULT UPON PORT HUDSON

the same phenomenon was repeated. This assault was delivered on the 14th of June, 1863. The weather on the 12th had become "clear and pleasant, with light breeze from northward;" but on the 16th it again rained heavily, with thunder and lightning, and with squalls of wind as before.[3]

I have mentioned the bombardment and passage of the Vicksburg batteries on the Mississippi by Admiral Farragut, on the night of June 28, 1862, as an engagement followed soon by a storm of rain with heavy thunder and lightning; and his passage of the Port Hudson batteries has also been referred to as succeeded by a tremendous and long-continued shower. It remained for Admiral Porter to try, at the former place, a similar experiment. We might naturally expect that, if Farragut could bring rain by steaming past rebel batteries and engaging them as he passed, Admiral Porter could do the same, and so it proved. As an exploit of war, the passage of the Vicksburg batteries by Porter equalled that of Farragut, performed at an earlier period. As a scientific experiment for the artificial production of rain, it was still more successful.

PORTER'S PASSAGE OF THE VICKSBURG BATTERIES

was made on the night of April 16-17, 1863. Eight

[3] Log of the Hartford.

gunboats passed down, and when opposite to the city, "in a moment the whole bluff was ablaze with the flashes and quaking to the roar of heavy guns rising, tier above tier, along the entire water front of the city."[4] The action lasted a little less than two hours, terminating at about 1 o'clock in the morning of the 17th. It occurred during a spell of "clear and pleasant" weather; but on the 18th, from 6 to 8 P. M., there was "rain at intervals," and from 8 to 12, "heavy squalls, with continuous thunder and lightning, and deluges of rain."[5] The rain continued to fall heavily until about 4 o'clock next morning.

The

BATTLE OF RAYMOND, MISS.,

fought May 12, 1863, was followed, on the 14th, between the hours of 9 and 11 A. M., by a tremendous shower.[6]

During the

SIEGE OF VICKSBURG, MISS.,

which commenced May 19, and ended July 4, 1863, there were numerous showers, though at that point they were not generally heavy. The following are some of the days on which it rained,[7] viz.:

[4] Am. Conflict, Vol. II. p. 301.
[5] Log of the U. S. Ram "Lafayette."
[6] Am. Conflict, Vol. II. p. 306.
[7] These dates and facts are taken from the Log of the "Blackhawk," except the first, which is from that of the "Benton."

May 22, 27, 28, and 31, June 10, 15, 16, 23, and 24. Besides the days on which there was rain, it was "cloudy, with appearance of rain," on the 21st of May; and cloudy at different hours on the following days, viz.: May 23 and 25, June 3, 5, 11, 17, 18, 19, 20, 21, 25, and 26; with "passing clouds" on the 27th and 30th. On these days it would generally become cloudy for only a few hours, and then clear off again.

While the circumstances attending this siege are not such as to afford strong evidence in support of the proposition that artillery firing can at all times be made to bring heavy rain, neither do they furnish evidence to the contrary.

Rain followed the

NAVAL ACTION OFF CHARLESTON HARBOR,

that ensued on the morning of January 31, 1863, when two iron-clad Confederate vessels came out and attacked the Union blockading fleet. The weather previously had been clear, and so remained until 8 A. M. of the next day. It then began to get cloudy; at noon the sky was completely overcast; at 7:30 in the evening there was a "light sprinkling of rain," and from midnight to 8 A. M. the weather is described simply as "rainy."[8]

During other operations by the army and navy in

[8] Log of the "Keystone State."

front of Charleston, in the year 1863, engagement after engagement was followed by rain. Of a long series of fights, there were but two where the phenomenon was not exhibited, and these were followed by overclouded skies.[9]

THE ATTACK ON THE DEFENCES OF SECESSIONVILLE,

on James Island, by General Hunter, was one of those where storm quickly succeeded battle. The engagement took place on the morning of June 16, 1863, and eight hours of continuous rain followed it, commencing between 7 and 8 o'clock in the morning of the 17th.[10]

The

ATTACK ON MORRIS ISLAND,

July 10 and 11, 1863, is another of the list. The bombardment, assault and capture of the batteries on the south end of the island was made on the 10th, and the unsuccessful attack on Fort Wagner on the 11th. The sky during the first day was cloudless; on the second it was cloudy in the morning and thickly overcast in the evening, and on the following night it rained with extraordinary violence.[11]

Another of this series of engagements was the

ATTACK ON GENERAL TERRY ON JAMES ISLAND,

made at daybreak on the morning of July 16, 1863,

9 Attacks of April 7 and Sept. 5, 1863.
10 Log of the U. S. Steamer "Pembina."
11 Log of the "Catskill."

and which was repulsed by the aid of five gunboats, which happened to be near. This was only a few days after the storm just mentioned, but it had passed off and none but detached clouds were visible in the sky. It commenced clouding up, however, about 5 o'clock in the afternoon; between 8 and 9 in the evening it had become rainy and squally, and at 11 it commenced to pour in torrents. This storm, which continued the greater part of the night,[12] and, after an intermission, through part of the night following, is spoken of in history as "terrible."[13]

Next in the list is the

BOMBARDMENT OF FORT WAGNER,

on the 18th of July, 1863. The gunboats commenced firing at 8.30 in the morning, and the larger vessels and land batteries at 12.30. "On our side fully a hundred great guns steadily thundered. * * * As the day declined the roar of our great guns, no longer incessant, was renewed at longer and longer intervals, and finally ceased; our iron-clads, save the Montauk, returning to their anchorage; while a thunderstorm burst over land and sea, sharp flashes of lightning intermitting and intensifying the fast-coming darkness."[14] * * *

[12] Log of the "New Ironsides."
[13] Am. Conflict, Vol. II. p. 476.
[14] Greeley's American Conflict, Vol. II. p. 476.

This storm continued until 4 o'clock the next morning.[15]

Again, on the 20th of July, as shown by the log book of the "New Ironsides," there was

HEAVY FIRING ON FORT WAGNER.

Rain followed in the night of the 21st, also on the night of the 22nd and 23rd.

Again, on the 24th of July there was

ANOTHER ATTACK ON SUMTER, WAGNER AND CUMMINGS POINT BATTERIES.[16]

Heavy rain followed, commencing at 1 A. M. on the 25th, and continuing until 11 A. M.[17]

Again, on the 28th of July there was

MORE HEAVY FIRING,

the "James Island batteries firing on our batteries, our mortar batteries firing on Fort Wagner."[18] Rain followed the next day at 2 A. M.[19]

The next engagement of this series was the one that ensued

WHEN GEN. GILMORE'S SIEGE BATTERIES OPENED FIRE

on Sumter, Wagner, and the Cummings' Point batteries. This was on the 17th of August, 1863, commencing at a very early hour in the morning. There was a light wind at the time from the north-

15 Log of the "New Ironsides."
16, 17, 18 and 19 Log of the "New Ironsides."

west, and the sky showed blue with detached clouds. At 7 A. M. the wind became variable, and at 2 P. M. it blew lightly from the southeast; at 6 P. M. the rain began to fall, and for four hours it poured without intermission.[20] The wind changed at 7 P. M. to the northeast, but it blew gently all that day, though we read in history that on the 18th and 19th a heavy northeaster raged.[21]

I do not doubt that my readers are wearied with the sameness of this recital, but I am not yet done even with the list of engagements before Charleston. On the 23rd of August, commencing at 3.15 and lasting until 6.30 in the morning, there was an

ATTACK BY FIVE MONITORS ON FORT SUMTER, MOULTRIE REPLYING.

There had been no rain since the storm last chronicled, nor were there apparently any indications of rain when the action commenced, though there was that morning a fog; but within less than twenty-four hours the sky became overclouded, and in another hour it rained.[22] The history of

ROSECRANS' ADVANCE

from Murfreesboro, Tennessee, furnishes a further instance of the remarkable connection between military operations and rain. There was a good deal

[20] Log of the "New Ironsides."
[21] Am. Conflict, Vol. II. p. 479.
[22] Log of the "New Ironsides."

of artillery firing in this movement,[23] and for seventeen successive days it rained every day.[24] The engagement at

LIBERTY GAP,

fought about the 24th of June, 1863, was followed by heavy rain.[25] The same is true of the [26]

BATTLE OF SHELBYVILLE,

fought on the 27th June, 1863. After this engagement, Elk River became so swollen as to stop for some days the pursuit of the retreating Confederates.[27]

The following may or may not be an instance worth recording of the occurrence of rain following the discharge of artillery. At Tebb's Bend, on Green River, in Kentucky, on the 4th of July, 1863, the rebel General Morgan, with a force of two regiments and four guns, made a desperate but unsuccessful attack on a Union force under Col. O. H. Moore, which lasted for several hours. The next day he spent seven hours, commencing at sunrise, in endeavoring to

REDUCE THE DEFENCES OF LEBANON.

A rain followed, for we read that he finally charged into the place, set it on fire and compelled its surrender; and that at dark a furious rain came on,

23 See No. 16, Appendix.
24 Am. Conflict, Vol. II., p. 409.
25 See No. 29, Appendix.
26 See No. 14.
27 See Am. Conflict, Vol. II., p. 410.

during which he raced his prisoners ten miles in ninety minutes to Springfield — all except one, who being unable or unwilling to keep up with the rest, was shot.[28]

A rain occurred also after

THE BATTLE OF CHICKAMAUGA, GA.,[30]

fought Sept. 19 and 20, 1863. A circumstance connected with the weather noticed after each day of battle was a dense fog; the one on the morning of the 20th was so thick that objects could scarcely be distinguished at a few steps distance.[31] The battle was fought in the woods, where but little artillery could be used, and where we might expect that the effect of concussion would be lessened by the interference of the trees with the movement of the air. The precise time when the rain occurred is not stated, but it is probable, from the reasons above given, that it was a little longer in "brewing" and less in quantity than the rains which generally follow great battles — a supposition to which additional probability is given by the fact that, by some who were present, this rain is not remembered.

AT THE BATTLE OF LOOKOUT MOUNTAIN,

fought on the 23rd and 24th of November, 1863, a

28 Am. Conflict, Vol. II. p. 405.
30 See No. 14, Appendix.
31 See Am. Conflict, Vol. II. p. 419. Also No. 8, Appendix.

circumstance occurred of a similar nature, and fully as remarkable as would have been the production of rain. On the 24th "darkness at 2 P. M. arrested our victorious arms, the mountain being now enveloped in a cloud so thick and black as to render further movement perilous, if not impossible."[32]

THE BATTLE OF MISSION RIDGE,

fought the next day, was followed by rain.[33] During Gen. Banks'

RED RIVER CAMPAIGN,

in the spring of 1864, in which there was more or less fighting daily for several weeks, there was much showery weather,[34] but the precise dates on which rains occurred I have not been able generally to ascertain. Probably many of them were showers which extended over only a limited space of country — as on the seventh of April we read that a heavy rain occurred which greatly retarded the rear of his extended column but did not reach its front.[35]

A FIGHT ON THE ATCHAFALAYA RIVER

has been mentioned[36] as one where the phenomenon was specially noticeable, from the weather previous to the fight having been so clear and bright.

32 Am. Conflict, Vol. II. p. 439.
33 See No. 29, Appendix.
34, 36 See No. 41.
35 Am. Conflict, Vol. II. p. 539.

THE ENGAGEMENT NEAR MARKSVILLE

(or Mansura), which took place May 16, 1864, was followed by nearly a week of rain.[37]

GEN. STEELE'S CAMPAIGN IN ARKANSAS,

made while Gen. Banks was operating in the adjoining State, was also attended with heavy rains,[38] some of which, it is not impossible, may have had their origin in the part of the country then occupied by the latter.

THE BATTLE OF MARKS MILL,

fought by a portion of his command on the 25th of April, 1864, was followed by rain, for we read that "by daylight of the 27th his army was across the Washita and in full retreat amid constant rains."[39]

ON SHERMAN'S ATLANTA CAMPAIGN,

which was a continuous battle for ninety days, there were heavy rains at short intervals.[40]

AT THE BATTLE OF DALLAS, GA.,

fought May 26, 1864, the circumstance was specially noticeable.

Great rains followed most of the battles of Gen. Grant's campaign against Richmond. The first engagement which took place upon his advance across the Rapidan was the

37 See No. 41 of Appendix.
38 Am. Conflict, Vol. II. p. 552.
39 Am. Conflict, Vol. II. p. 553.
40 See Nos. 3, 8 and 29, of Appendix.

BATTLE OF THE WILDERNESS,

fought May 5 to 9, 1864, the heaviest fighting being on the 5th and 6th, and being for the most part an infantry battle, as it took place in the woods, where artillery could not be used to advantage. A little rain appears to have fallen[41] on the 8th or 9th, which increased to heavy thunder-storms after the first day of the

BATTLE OF SPOTTSYLVANIA COURT HOUSE,

which was a continuation of the Wilderness battle, and one in which much artillery was brought into action. This terrible battle was fought on the 10th, 11th, and 12th. Heavy rain set in on the night of the 10th.[42] On the afternoon of the 11th it also rained heavily. On the morning of the 12th there was a fog of exceeding density, and at noon rain set in again and fell in torrents, accompanied with thunder and lightning.[43] This storm extended over a hundred miles southeastward, and there lasted, with varying intensity, until midnight of the 13th.[44]

GEN. BUTLER'S BATTLE OF BERMUDA HUNDREDS,

fought on the morning of May 16, 1864, was followed by rain in the evening.[45] There was also

41 See No. 26.
42 See No. 33.
43 See Nos. 2, 25, 33. Also Am. Conflict, Vol. II. p. 571.
44 Log of the U. S. Steamer, "Commodore Perry," on James River.
45 Log of the U. S. Steamer, "Agawam," on James River.

rain on the 18th and 19th, on both of which days there was fighting along his front.

GEN. GRANT'S BATTLE OF NORTH ANNE RIVER,

which was the next battle of his campaign after that of Spottsylvania, was followed by a heavy storm of rain, accompanied with thunder and lightning.[46] The battle was fought on the 23rd of May, 1864, and the storm commenced the day after,[47] and lasted during portions of three days.[48]

A spirited

FIGHT AT HAWES SHOP,

which occurred on the 28th of May, and in which the aggregate loss on both sides was some 1,200 men, was followed in the night of that day by rain[49] on James River.

Tremendous rains accompanied and followed the

BATTLE OF COLD HARBOR OR BETHESDA CHURCH,

which was the next engagement of this campaign. This fearful battle was fought on the 1st, 2nd, and 3rd of June, 1864; the commencement, on the 1st, being at 4 o'clock in the afternoon. So far as can be known from the state of the weather some fifty miles southeastward, there had been no rain since the night of May 28; and the battle was com-

[46] See No. 25, Appendix.
[47] Am. Conflict, Vol. II. p. 579. Also Log of Steamer Agawam.
[48] Log of U. S. Steamer Agawam.
[49] Log of U. S. Steamer Agawam.

menced under a cloudless sky.[50] But on the night of the 2nd there was a heavy rain; the next night there was another, and the third day of battle was followed by a third. Each separate day's encounter seems to have been followed by a separate rain, and the last—the one in which, for a time, the fighting was so furious that in the space of twenty minutes "fully ten thousand of our men were stretched writhing on the sod, or still and calm in death"[51]—was followed by one of some twenty-four hours' duration, commencing in the afternoon of the succeeding day.[52]

The following are some of the other engagements of this campaign that were followed by rain, viz.:

FIGHT AT BAILEY'S CREEK,

August 12, 1864. Rain followed on the 14th.[53]

A SECOND ENGAGEMENT AT BAILEY'S CREEK,

August 16, 1864. Rain followed on the 17th.[54] Battle for the possession of the

WELDON RAILROAD,

fought August 18, 1864. Thunder-storm followed in the night.[55]

50 Log of the "Agawam."
51 Quoted from Am. Conflict, Vol. II. p. 582.
52 Log of the U. S. Steamer "Agawam," on James River. See also No. 2 of Appendix.
53 54 Log of the Steamer Agawam.
55 56 See 25 and 36, of Appendix.

Two other engagements occurred on the line of the Weldon Railroad, August 21, 1864. Same remark as to the above.[56]

ASSAULT AND CAPTURE OF FORT HARRISON,

September 29, by General Butler. Rain next afternoon[57] on James River.

ATTEMPT TO RETAKE FORT HARRISON,

by the rebels, September 30, 1864. Rain in the night and next forenoon on James River.[58]

BATTLE ON THE SQUIRREL LEVEL ROAD.

Heavy rain immediately after.[59] At a point on the James River, the shower occurred between 8 P. M. and midnight of the same day.[60]

ACTION AT THE FRONT,

October 2, 1864. Rain next afternoon.[61]

BATTLE OF HATCHER'S RUN,

fought October 27, and the last one of Grant's battles for the year 1864. A heavy storm followed, accompanied with thunder and lightning.[62] At a point on the James River the rain poured for seven hours[63] during the night after the battle.

In West Virginia, the

57 58 60 61 63 Log of the Steamer Agawam.
59 See No. 24.
62 See Appendix, Nos. 24 and 25.

FIGHT AT DUBLIN BRIDGE,

May 10, 1864, was followed by a fall of rain.[64]

In the Virginia Valley, the

BATTLE OF NEWMARKET,

fought May 15, 1864, was also followed by rain.[65]

There was some

CANNONADING AT MARYLAND HEIGHTS,

on the night of July 6, 1864, and sharp fighting on the 7th, which was followed, on the night of the 7th, by a little rain, and on the next night by an "awful rain." The previous weather had been very dry.[66]

THE BATTLE OF WINCHESTER

(Crook's), fought July 24, 1864, was also preceded by a long spell of dry weather; but the next day there was a hard rain.[67]

The general character of the weather in the Shenandoah Valley in the months of August and September, 1864, was that of drouth, and it is only remembered as such by an officer who has favored me with a communication upon the subject.[68] Yet an actual record that was kept of the weather in that section, during a part of the time mentioned, shows frequent instances of

64 See No. 17. 65 See No. 23. 66 See No. 18.
67 and 68 See Appendix, Nos. 17, 18 and 23.

RAIN FOLLOWING ARTILLERY SKIRMISHES.[69]

I quote:

August 17. "Clear at daylight." "Heavy fire of artillery" during the day.

August 18. "Rain."

August 19. "Skirmishing near Berryville."

August 20. "Rain."

September 3. "Cloudy; heavy artillery and musketry in the direction of Berryville." "Rain."

On the same day. "Still fighting far away into the night." Next day. "Rain."

Skirmishing also on the 4th. Rain on the 5th.

Also on the 5th, "Skirmishing heavy." September 6, "Rain all day."

September 9, "Smart skirmishing." September 10, "Rain." September 12, "Rain."

September 13, "Clear;" "Cannonading heavy." September 14, "Rain·" 15, "Cloudy;" 16, "Rain."

The above memoranda were made by a Confederate officer, who was killed at the battle of Opequan Creek, near Winchester, Sept. 19, 1864, and some extracts from whose diary have been published.[70]

What entry he would have made had he lived after that battle and the battle of Fisher's Hill, fought

[69] See No. 18.

[70] In Putnam's "Record of the Rebellion," Vol. XI. p. 153.

three days later, remains a mystery; but in the southeastern part of the same State (Virginia) it rained hard soon after each of those battles—the first rain occurring on the night of the 21st and the second about the middle of the day on the 23d.[71]

At the naval action and the bombardment of the forts at the entrance of Mobile Bay, further instances of the phenomenon under consideration were exhibited. There had been a shower on the day preceding the commencement of operations, but the weather on the evening of that day, and at the commencement of the first engagement, was such as the words, "blue sky with detached clouds," are used in the navy to describe.

THE PASSAGE OF THE FORTS AND BATTLE WITH THE GUNBOATS,

which took place on the morning of August 5th, commencing at 6.45 A. M., was followed by about two hours of rain, which commenced at nine o'clock A. M.[72]

THE BOMBARDMENT OF FORT GAINES,

on the 6th, was followed by a thunder-shower on the 8th.[73]

[71] Log of the Steamer "Agawam" on James River.
[72] Log of the U. S. Steam Sloop "Hartford."
[73] and [74] Log of the U. S. Steam Sloop "Hartford."

THE BOMBARDMENT OF FORT MORGAN,

on the 9th, was followed by two excessively stormy days on the 10th and 11th, on which there was rain, thunder and lightning and squalls of wind.[74] The rain which fell at this time is described by an officer who was present, as exceedingly copious.[75]

THE BATTLE OF FRANKLIN, TENN.,

was followed by a rain that froze as it fell, and covered the country with ice.[76] This battle was fought Nov. 30, 1864.

THE BATTLE OF THE CEDARS

was also immediately followed by rain.[77] This battle was fought shortly after the battle of Franklin, by troops under Gen. Milroy, sent from Murfreesboro to the relief of Fortress Rosecrans, invested by the rebels Dec. 4.

THE GREAT BATTLE OF NASHVILLE,

fought Dec. 15 and 16, 1864, was followed by one of the most tremendous rains that have ever been noticed in connection with military operations.[78] For several days the rain fell incessantly. "The country was flooded; the brooks were raging rivers," and "the roads were hardly passable in the rear of the fleeing foe."[79]

[75] See No. 4 of Appendix.
[76] and [77] See No. 5.
[78] See Nos. 5, 28 and 29 of Appendix.
[79] Am. Conflict, Vol. II. p. 687.

AT THE BOMBARDMENT OF FORT FISHER,

Dec. 24 and 25, 1864, we again find rain following heavy explosions. The experiment which was tried of exploding a shipload of powder under the walls of the fort, took place at 1.45 A. M. of the 24th, and the bombardment by the fleet commenced at half-past 11 A. M., and continued during the remainder of the day. The next day it was renewed for seven hours. On the first day there were no indications of rain, nor had there been on the day preceding; but on the second day, at 1 o'clock in the afternoon, it became cloudy, and at 7 in the evening rain commenced, which continued through the greater part of the night. During the first part of the night it only drizzled, but in the latter part for two hours it rained heavily. The morning that followed was rainy and squally, and after an intermission rain fell again in the middle of the day for about an hour.[80]

THE SHELLING OF THE WOODS

by the gunboats on the 27th, during the re-embarkation of troops belonging to the expedition, whose operations at Fort Fisher have just been noticed, was followed by more rain on the 28th, though on the 27th there had been none.[81]

The expedition against Fort Fisher above referred

[80] Log of the U. S. Steamer "Malvern."
[81] Log of the Steamer "Malvern."

to will be remembered as the one which was unsuccessful. But the

SECOND EXPEDITION AGAINST FORT FISHER,

and the one that effected its capture, met, in the character of the weather that attended its operations, a somewhat similar experience. In the latter case, however, the storm was principally hail instead of rain. The operations of the fleet commenced in a heavy bombardment in the night of January 12, 1865, to cover the landing of the troops. There were no clouds during the day, except detached ones, and from 9 P. M. until midnight the sky was perfectly clear. But in the afternoon of the 13th there was a hail storm, commencing at 2 P. M., and lasting, with an intermission of two hours, until midnight, after which it broke away.[82]

THE FIRING IN THE NIGHT

of the 13th was followed by a second change of weather on the 14th, the sky becoming overcast for four hours;[83] but the weather afterwards returned to its normal condition—"blue sky with detached clouds."

The bombardment, assault, and capture of the fort on the 15th, was followed on the 16th by two hours of drizzling rain.[84]

[82] Log of the U. S. Steamer "Malvern."
[83], [84] Log of the U. S. Steamer "Malvern."

THE BATTLE OF AVERYSBORO, N. C.,

fought March 18, 1865, was also followed by rain. History relates that at the close of this battle, "Night fell dark and stormy."[85]

THE BATTLE OF BENTONVILLE, N. C.,

fought March 18, 1865, was likewise followed by rain, which on the 21st was heavy.[86]

We have seen that at the bombardment and capture of the lower forts at Mobile Bay, rain followed each operation of the fleet. The same is true of the operations of the army of Gen. Canby, and fleet of Rear-Admiral Thatcher, in the

REDUCTION OF THE UPPER FORTS AND CAPTURE OF THE CITY OF MOBILE,

months of March and April, 1865.

The preliminary firing by the army and navy in approaching the city was followed by rain on the evening and night of March 27.[87] The nature of some of this firing is shown by the following extract from the New York *Times* of April 7, 1865, viz.: "Gen. Steele's command met with much opposition, but no regular battle was fought until at Mitchell's Fork, on the morning of the 27th, where the enemy, numbering 800, made a stand,

85 Am. Conflict, Vol. II. p. 707.
86 Am. Conflict, Vol. II. p. 708.
87 Log of the U. S. Steamer "Octorara."

and after a severe fight were repulsed." There was also some gunboat firing about this time, and two of our vessels were blown up by torpedoes and destroyed. Previous to this rain there had been none for five or six days at the place or places of observation of the steamer "Octorara," one of the vessels engaged in the operations.

THE SIEGE OF SPANISH FORT

was opened on the 28th. The firing of this day and the next was followed by a heavy thunder-storm in the night of the 29th, accompanied with squalls of wind.[88]

Several other showers occurred, the last being on the 9th, the last day of the siege, and following the tremendous fire which was concentrated on Spanish Fort at nightfall on the previous day, and which effected its reduction.

The rain which followed the various engagements of this and the former expedition against Mobile, is described by an officer who was present, as more copious than any he had ever before witnessed.[89]

THE BATTLE OF DABNEY'S MILL, VA.,

fought February 6, 1865, was followed next morning by a fall of snow.*

At the renewal of active operations before Rich-

88 Log of the Octorara.
89 See No. 4 of Appendix.
* See No. 83 of Appendix.

mond in the spring of 1865, storm still followed battle.

THE GENERAL ADVANCE BY GRANT'S ARMY

was made on the 29th of March, 1865, on which day was fought the battle of Quaker Road, and all that night and next day rain fell heavily.[90]

The last instance of the kind drawn from the late war of the rebellion which I shall mention is the

BATTLE OF FIVE FORKS,

immediately preceding the capture of Richmond. This battle, fought March 31, 1865, was, like so many others before it, followed by rain.[91] Before the battle commenced, the storm which followed the previous battle had ceased.[92]

So far I have only given instances of rain following the discharge of artillery occurring in the United States and Mexico, and in wars in which the army and navy of the United States took part. But in other parts of the world the same phenomenon has been noticed. The first instance that will be mentioned is one that was observed in the harbor of Rio de Janeiro, by one of our naval officers, in 1843 or 1844, on the occasion of the arrival there of the Princess of Naples, afterward Empress of Brazil. She was accompanied by the

90 Am. Conflict, Vol. II. p. 731. See also Nos. 2 and 33 of Appendix.
91 See No. 2.
92 Am. Conflict, Vol. II. p. 731.

Neapolitan and Brazilian squadrons, and upon her arrival, the fortifications and foreign squadrons began to fire. The firing continued for an hour or more, when the sky was suddenly obscured, and heavy showers followed. Previous to this, the weather had been clear and beautiful. The next day was calm and partly overcast; as soon as the firing of salutes was resumed, the breeze sprang up, and the rain began to fall.[93]

THE BATTLE OF DRESDEN,

was fought on the 26th and 27th of August. "On the 27th the battle was renewed, under torrents of rain, and amid a tempest of hail." (Scott's Napoleon, chap. 27, p. 190.)[94]

THE BATTLE OF LIGNY,

fought on the 16th of June. "After the battle the weather was dreadful, as the rain fell in torrents." (Scott's Nap. chap. 27, p. 323.)[95]

THE BATTLE OF WATERLOO,

is said to have been followed after thirty-six hours by a long rain; but reliable authority for this statement can not be here given.

THE BATTLE OF EYLAU,

fought on the 8th of February. "The action commenced at daybreak. Two strong columns advanced

[93] See No. 87 of Appendix. [94], [95] Espy's "Philosophy of Storms."

for the purpose of turning the right and storming the centre of the Russians, but they were repulsed in great disorder. The Russian infantry stood like stone ramparts, and kept back the enemy with a heavy and well-sustained fire from their artillery. About midday a heavy storm of snow commenced falling, which added to the obscurity caused by the smoke from the burning village of Serpallen." (Scott's Nap.)[96]

Capper on Monsoons, page 171, says:

AT MADRAS, ON THE 4TH OF JUNE, 1776,

"morning fair, noon cloudy, in the evening rain. N. B. More than two hundred pieces of cannon fired in salutes; *quære* whether it occasioned the rain? This *quære* is particularly appropriate, as this is the dry season on the Coromandel coast, and it did not rain after this till the 30th of the month."[97]

"During the

SIEGE OF VALENCIENNES

by the allied army, in the year 1793, it rained violently every day soon after the heavy cannonading commenced. The allies employed 200 heavy ordnance, and the besieged had about 100, and they were frequently all in action at one time."[98]

M. Arago says, "I shall here repeat two facts which occur to my own memory, in the hope that

96, 97, 98, Espy's "Philosophy of Storms."

they will lead to analogous statements. On the 25th of August, 1806, being the day selected for the

"ATTACK ON THE ISLET AND FORTRESS OF DANNHOLM, NEAR STRAUSLAND,

"General Fririon, that he might harass and fatigue the Swedish garrison, ordered it to be cannonaded during the whole day. In spite of these powerful and continued discharges of artillery, a violent thunder-storm visited the spot at 9 o'clock in the evening. Again it happened, oddly enough, that

THE ENGLISH LINE OF BATTLE SHIP, THE DUKE,

of 60 guns, was struck with lightning, in the year 1793, whilst it was cannonading one of the batteries of the Martinico." [99]

During the late war between France and Prussia, the occurrence of storms of rain after battles was specially noticeable, particularly so in the months of August and September; and the accounts from the battle-fields contained many allusions to the subject. For instance, immediately after the

BATTLE OF SEDAN,

at which the French emperor was taken prisoner, we read, in a telegram dated Donchery, September 3, "It is raining torrents."

Again, at the bombardment of Strasburg, in a

[99] Espy's "Philosophy of Storms."

dispatch dated Strasburg, September 8, *via* London, 10th, we read, "There are daily thunder-storms and the Rhine has risen, driving the inhabitants from their cellars."

Such accounts, bringing to mind occurrences of a similar nature which took place in our own war, and which strongly impressed the writer at the time with the idea of the practicability of obtaining rain at will by the use of gunpowder, led him to believe that the time had come when some experiments ought to be made in the matter, other than those which are incidental to battles and sieges, and determined him to ask the co-operation of those who had observed the phenomena in question, in bringing the subject forward. The day after the first publication of an article written with this view, a letter appeared in the New York *Evening Post*, showing that the matter had already received much attention on the other side of the Atlantic, and giving many facts bearing upon it. The letter is dated at Frankfort-on-the-Main, Sept. 14, 1870, but was not published until October 5. The following are some extracts:

"Since the commencement of actual hostilities between Germany and France—that is, from about the first week in August—to the present time, we have had in this part of Germany scarcely a day without rain, generally continuous, and often accom-

panied with thunder-storms. This phenomenon has called the attention of the German press to the subject, and some valuable historical facts connected therewith have been brought to light; and there appears to be little doubt, judging from the data on hand, that the many storms and rains which we have had in Germany for the past six weeks—a most unusual thing at this season here—have been brought on by the cannonading and firing of small arms in Alsace and Lorraine.

"The Leipsic *Illustrirte Zeitung* calls to mind a remarkable phenomenon observed in the revolutionary year 1849. The city of Ofen lies on the banks of the Danube, here running due south. The hill on which the fortress is situated has an elevation of two hundred and thirty-eight feet above that river. It is surrounded on three sides by mountains: on the south by Gernhardsberg, on the southwest by the Adlersberg, on the west by the Schwabenberg (one thousand two hundred feet high), and on the north by the Geisburg (also one thousand two hundred feet high). As the insurgents, at noon, on the 4th of May, 1849, approached the fortress, the latter commenced firing eighty-four guns, eighteen and twenty-four pounders, in order to prevent the besiegers from planting their batteries. Towards evening the cannonading on both sides was furious, and a stable in the fortress was already on fire. The

sky, which had been perfectly clear for a number of weeks, became overclouded, and towards midnight a gentle, fine rain fell, the wind being perfectly calm and the shower continuing from one till three. A clear morning followed. The previous fine weather continued up to the evening of the 17th, when a fearful storm raged, coming as usual from the west. A house on the Schwabenberg was struck by lightning, and the storm ended with a cloud-burst which cost the besieged the lives of a number of horses and men. This storm is supposed to have been produced by a

SIX HOURS BOMBARDMENT OF THE CITY OF PESTH,

by General Hentzi, from Ofen, on the 13th of May, during which engagement six immense mortars of great calibre produced tremendous concussions for a distance of several miles around.

"In the year 1859, an uncommonly violent hail-storm fell in the faces of the Austrians during the battle of Solferino. * * * *

AFTER THE FIRST BATTLE IN THE LAST WAR BETWEEN FRANCE, SARDINIA AND AUSTRIA,

there followed such important rains that even small rivers were impassable; and,

DURING THE GREAT BATTLE OF SOLFERINO,

there broke out such a violent storm that the fight-

ing was interrupted. In July, 1861, McClellan's troops, on the upper Potomac, had four separate engagements on four days, and before the close of each, violent rains fell. * * * *

"The Bohemian campaign of 1866 was accompanied during the whole course by violent rains. After

THE BATTLE OF KŒNIGGRATZ,

violent rain storms hindered the harvest from being properly garnered.

"The letters of the soldiers in the field, in the present war, are full of accounts of 'sleeping on the wet ground,' and complaints of the inclemency of the weather. The 5th of August following

THE BATTLE OF WEISSENBERG,

was intensely warm. The night of the 6th was rainy, and the morning following

THE BATTLE OF WOERTH,

when the telegrams of victory came, found the streets full of water-pools and the sky overcast with gray, heavy clouds. Since then, we have not had six fine cloudless days. 'From the 6th to the 31st of August,' says the *Illustrirte Zeitung*, 'it rained every day, often accompanied by thunder; and these continuous and violent rains have caused great damage in those districts where the harvest was not in before the 6th; the corn has been washed out, the

straw has been rotted, and the crops have no more value.'

"THE BOMBARDMENT OF STRASBURG

is accompanied by the grandest meteorological spectacles. The thunder of the cannon, the blazing of the houses, and the curve fire of the shells, are often intermingled with the roar of thunder and the flashing of lightning. The storms seem to come from the Vosges, to break over the doomed city, and then to spread over the valley from the Rhine to the Schwarzwald, where the grass and trees are almost as green as in spring; and it is well known that, when the war was declared, Baden, Alsace and France were suffering from drouth. Great rains fell in Hungary on the 15th of August, the day after

THE FIRST BATTLE AROUND METZ.

In Germany the grapes will be spoiled unless the sun shines with its usual power. We are inclined to think that the storms here are caused by the firing in Alsace, and, up to a week ago, by the bombardment of Strasburg. For the past three or four days fine weather has set in; and it is a fact that the firing at Strasburg is no longer carried on so strongly, the King having sent orders that the city should now be spared as much as possible from shells. We have had thunder-storms here which

surpassed in grandeur and power everything in the experience of the 'oldest inhabitant.'"

That the operations of armies will bring rain in otherwise rainless countries seems to be shown by what took place during the

CONQUEST OF KHIVA, ASIA,

by the Russians, as detailed in the letter of the celebrated war-correspondent, J. A. MacGahan, which will be found in the Appendix. It is not claimed, however, that the facts detailed are of special significance in connection with this subject, in view of the uncertainty as to precisely when the cannonading referred to occurred. The principal value attached to them is in that they add confirmation to a principle elsewhere more fully brought out, that the dryness of the air of any country does not preclude the possibility of rain. Rain comes from humid currents; and if a rainless country has such currents flowing over it, it may have rain no matter how dry the air may be at the earth's surface.

Peru in South America is another so-called rainless country; yet in August, 1873, a heavy rain occurred there lasting three hours and inflicting a damage estimated at over a million dollars; the roofs of the houses in that country not having been so constructed as to shed rain. While there are no precise data to indicate how this rain was brought on, whether by

in the mountains or otherwise, yet it was supposed to have been caused by the operations of Henry Meiggs in the construction of railroads in that country; and the people of Lima gave him the credit—or rather the discredit of it. An interesting account of this rainstorm and of the consternation which it caused was published in the Chicago *Tribune* of September 7, 1873.

The foregoing facts, showing that in different parts of the world, and in all seasons, heavy artillery firing is almost invariably followed by rain, are believed to be sufficient to establish fairly well, if not perfectly, the proposition that to produce this phenomenon at will is within the reach of human power. Some of the storms which have been mentioned would doubtless have occurred if there had been no cannonading; indeed, in such a large number of days, the chances are that, on some, rain in any case would have fallen. But no calculation of chances can make it appear a reasonable supposition that rain would have occurred on all, through the ordinary operations of nature alone. The average annual number of thunder-storms in the latitudes of the United States, is a fraction less than 20*—a number totally insufficient to give them with the

* The average of thunder-storms annually, between latitudes 30° and 50° is 19 9-10.—*Silliman's Philosophy*, p. 660.

almost unfailing regularity with which they occurred.

We have seen that, in our late war, almost every battle of the Eastern armies was followed by rain; that rain followed all the great battles of the West, and most, if not all, of the battles of the South; that it not only followed single battles, but frequently each engagement of a series; that on land and on the water, in the interior and on the coast, on the Mississippi, on the Gulf and on the Atlantic, again and again, storm followed battle; and that the phenomenon, confined to no section, was also peculiar to no season. We have seen that not only in our late war, but in the Mexican war, as well, it occurred again and again, and even in the very midst of the dry season; and that in North America, in South America, in Asia and in Europe, it has occurred under circumstances which compelled the attention of the observers. These facts have a significance that can not be lightly set aside, and if they do not furnish the positive proof, they fully warrant the belief, that artillery firing always tends to bring rain, and is often the actual cause of its occurrence.

But the question will naturally arise, why is not every battle followed by rain—why is it that an amount of artillery firing that in one case brings rain, will sometimes fail to bring it in another?

This question can be better answered after a further consideration of theories as to how cannonading produces rain at all; but it may be remarked here, that it is by no means certain that heavy cannonading does not invariably cause rain somewhere, even if it does not at the spot where the firing occurs.

In twelve instances of heavy firing by the naval and military forces operating against Charleston, that I have investigated, occurring from January 31 to September 5, 1863, ten were followed by rain, and each of the others* by an overclouded sky. In one of the latter cases the sky became overclouded for sixteen hours on the second day after the engagement, and in the other case for twelve hours on the day after; from which facts it may fairly be surmised that it rained in both cases at some place not far distant.

If it be admitted for the sake of argument, however, that heavy artillery firing sometimes fails to produce rain, either at the spot where the firing occurs or at any place in range of the air currents which exist at a high elevation—still, this would not be evidence that a way may not be discovered to so conduct the firing as to bring rain at all times with unerring certainty. It is probably in the manner of the firing, as well as in the amount, that we

* Attacks of April 7 and Sept. 5. Log of the New Ironsides.

must look for the peculiar influence that brings the rain. If it be the heat alone that the firing evolves that exerts that influence, then it would depend principally upon the amount; but I do not believe such to be the case. Professor Espy, some years since, claimed that he could cause rain by means of great fires, and cited rains following battles and conflagrations as facts in support of his theory. He maintained that all rains were caused by an ascending current of air, which drew the air to it from all directions, and that the condensation of the aqueous vapor was due to the cold caused by the expansion of the air as it rose. He believed that all that was necessary, in order to bring on a rain, was to build a great fire so as to heat the air and cause it to ascend, and that after an ascending column was once formed, the fire might be allowed to go out, and the upward current would still continue. The manner in which the process would go on—and, according to his theory, the process is the same in the case of any rain—may be thus described: The air, as it rises, expands; by its expansion it becomes cold; by its cold a portion of its aqueous vapor is condensed into cloud; by the latent heat given out in this condensation, the air is warmed and made to rise higher, causing a further expansion and a further condensation of vapor: the surrounding air, in the meantime, rushes in to take the place of that

which is thus ascending and passing off, and goes through the same process.

But though Professor Espy's philosophy contains much that has been generally accepted by meteorologists as true, and though there seems to be abundant evidence that great conflagrations and volcanic eruptions sometimes bring rain, yet he was probably mistaken if he believed that it was practicable to bring rain in the way he proposed in sufficient quantities to be of service to agriculture and at a cost which would make it pay as an economic measure. To cause rain by building a great fire would be too expensive a proceeding. It would require too large a fire to be practicable, and its effects at different times would be too variable and uncertain. Even the great fire which destroyed the city of Chicago in 1871 produced but a moderate shower; but this can scarcely be taken as a fair example, as there was such a heavy wind blowing at the time of the fire that the heat was carried off and scattered too much to produce the effect it would otherwise have done upon the higher air-currents.

But Espy's plan, though impracticable, had the merit of being much like one of the ways in which nature works to bring about the result in question. There are different ways in which nature sets in motion that mingling of air-currents which

is necessary, in our latitudes, to produce rain. Sometimes the motions of the currents themselves may bring them into conflict from causes too remote for our present inquiry. Sometimes the tides in the great ocean of the atmosphere, caused by the attraction of the sun and moon, may have an influence in that direction. At other times the lower current strikes the side of a mountain and is deflected upward into the current above. This, no doubt, is the way in which most of those storms originate which start in the Rocky Mountains and travel eastward across the United States and Canada. Another way is when, at some sheltered point or on some still, warm day, the heat of the sun causes a column of warm air to rise so as to destroy the equilibrium of the air currents above. This I believe to be the way in which great fires act to bring rain. From what I have said of Espy's theory, however, it will be seen that this is not his explanation; for he found in the surface air the vapor for his rains. He did not recognize vapor-bearing currents from the tropics as the great and immediate source of our rains. But at the time he wrote, Professor Maury had not worked out his theory of the circulation of the atmosphere nor was the significance of the eastward movement of storms appreciated, though this movement had been recognized. Both of these, however, are great facts which can not be ignored in

any theory dealing with the subject at the present day.

When cannonading brings rain a different force from heat is brought into action, and this force is concussion. It acts in a different way from heat, and its action is more certain and effective.

I have advanced and emphasized the idea that the greater portion of the rains that fall within the United States are drawn from vapor that comes from the Pacific Ocean. A reliable authority has estimated that enough water evaporates from the ocean in a single year to depress its whole surface eight or ten feet if none went back; while by some the amount is estimated to be even greater than this. Some of this vaporized water falls back as rain directly into the ocean—the rest is carried in great air currents over the continents, where it is precipitated as rain or snow, and runs back by the rivers again to the ocean. Some of it may be long in thus returning. Portions of it may be many times evaporated from the earth and many times fall as dew, or, after evaporation, rise to a high elevation, and be drawn with portions of the lower air into the vortex caused by mingling air currents, and be condensed and fall again as rain; but in time it must all go back to the sea, while constantly from the sea comes more vapor to keep up the supply.

The atmosphere surrounding the earth has a cir-

culation which, speaking in a general sense, is definite and uniform from year to year, though modified somewhat by the seasons. This circulation is caused by the heat of the sun acting unequally upon it in different parts of the world, and acting on different portions of it successively, owing to the revolution of the earth on its axis.

The vapor-bearing current that supplies moisture to the United States is vast in extent and covers the whole country. It receives its force and motion from the southeast trade wind of the Pacific Ocean and is, in effect, a continuation of that wind, being composed of the same air as that which, as a trade wind, was wafted two thousand miles over the Southern seas. The vapor which it bears along comes principally from that portion of the ocean which lies within the tropics. It is probable that the air containing this vapor is very warm and very fully saturated with it. It is not necessary to my theory that the whole body of this great eastward moving current should be equally warm and equally saturated with vapor—the different parts can be in equilibrium without being so—but it is probable that there is everywhere and always a stratum sufficiently saturated to produce rain; except, perhaps, at such times as it may be parted or broken by waves of colder air. This warm current from the tropics is called the Equatorial current. The South-

ern Hemisphere also has an equatorial current produced by the northeast trade wind.

Above the equatorial current there is a cold current called the Polar current flowing in nearly the opposite direction. As cold air can not hold as much vapor as warm air even in proportion to its temperature, the polar current contains but little vapor, but it may contain as much as it is capable of holding at its existing temperature; for this cold current was once a warm, saturated current from the tropical seas. It was first a trade wind, then an equatorial current, and lastly, a polar current. It has travelled many thousand miles since it left the equator and has taken part in many storms, first as a lower current, and then as an upper current. It has circled around one of the poles of the earth, and is now returning to again form a part of one of the trade winds, and go through the same round as before. During every storm in which it has taken part as a polar current it has received to itself portions of the warm current below it and portions of the surface air lying between the warm current and the earth, and has left behind portions of itself. It has lost most of its vapor, but not all.

When contiguous portions of the equatorial and polar currents mix together, rain is the result. A circular motion is produced by the union of the two currents. There is also an upward movement of

air within the storm area; for as the vapor condenses, latent heat is given out, which expands the air in which the condensation takes place and makes it lighter, bulk for bulk, than it was before. And not alone by the release of latent heat is the air made lighter, but the withdrawal from it of the vapor contributes directly, also, to that result. As the air of the mingling currents thus rises, it draws into the motion the surface air, thus communicating to that air, to a considerable extent, the circular motion above mentioned, and also giving to it an inward motion toward the centre of the storm. It is not unlikely that there is also in the vicinity of where the action is greatest a downward motion. There may be no positive proof of this, but we may reason that it is so from general principles; for we know that in the economy of nature, the beneficent effects of rainstorms are not confined to furnishing moisture for vegetation and water for man's use; they are a part of the machinery provided for mixing the atmosphere so that its constituent elements are kept in the same proportion in all parts of the world. Besides the motions which have been mentioned—circular, upward and inward, with possibly a downward—the whole storm has a motion eastward or northeastward. This is one of the fundamental laws which guide the officers of the Signal Service in their predictions of the

weather. It is not negatived by the fact that an east wind often precedes and accompanies a storm. When this is the case at any place it indicates that the storm centre is passing to the south of that place. The east wind does not bring the storm. The storm is brought by the equatorial current, and moves with it. The east wind is caused partly by the circular motion which the air in the two currents takes on when they unite, and partly by the suction caused by this air rising and passing off as it parts with its vapor. This circular motion is always, in the Northern Hemisphere, in the reverse direction to the motion of the hands of a watch, and in the Southern Hemisphere it is always in the same direction as the hands of a watch. We can easily see why the direction should be different for the two hemispheres when we consider that the equatorial current, in the Northern Hemisphere, flows in a northeasterly direction, while in the Southern Hemisphere it flows in a southeasterly direction; and further, that the polar current crosses the equatorial in the Northern Hemisphere from the northeast and in the Southern Hemisphere from the southeast.

Sometimes spurs of these currents unite and reach down to the earth, causing tornadoes, the source of whose terrific power is a problem difficult to solve, and of which I shall have more to say

further on. It may be stated here, however, that tornadoes always revolve in the same direction as other storms, showing that the primary cause of the revolution is the same in both cases.

Returning to my main subject I would say that anything that will cause the equatorial current to mix with the polar current above it will bring rain. This is what concussion does when a large number of cannon are fired and the firing is rapid and long continued.

But how does concussion do this? I shall reply by suggesting different explanations, either one of which, I trust, will stand the test of common sense and be found not to conflict with any known laws of physical science. Facts are of more importance than theories, but in order that a knowledge of facts may lead to the most useful results it is necessary that they should be supplemented by reasonable theories. Such theories may not at the outset be absolutely correct, and if with the progress of knowledge these theories should be found to contain error they should be changed to meet new facts as they transpire.

Let us then, first, consider concussion as an actual force capable of causing motion by direct action. The violent effects of heavy concussions in certain cases are too well known to need more than a passing notice. The breaking of windows by the

discharge of cannon is not an unusual occurrence. The statement that water-spouts at sea are broken up by the discharge of cannon is one with which all are familiar. Cannon firing is often employed to cause the bodies of drowned persons to rise to the surface of the water. A less familiar instance of its effects was seen at the bombardment of Forts Jackson and St. Philip in the number of dead fish that floated down the river. In this connection also I would call attention to what is said in the interesting letter of Gen. McNulta* which will be found on another page in relation to the effect of the firing at the inauguration of Gov. Hahn at New Orleans on the smoke issuing from the chimneys of the city. A kind of pressure seemed to be exerted very much greater than would be supposed.

These circumstances render not unreasonable the idea that the effect of artillery firing upon a horizontal current or moving stratum of air may be very great. Such a current, being necessarily in exact equilibrium with the air above and below it, would yield to the slightest force, and it may easily be conceived that the concussion produced by a number of cannon fired simultaneously would cause it to bend upward. Apply the idea to the case of two currents, one above the other and moving in a different direction, the upper one cold and the

* No. 4 of Appendix.

lower one warm, and both containing as much aqueous vapor as their respective temperatures will permit. The effect of heavy concussions often and quickly repeated would very likely be to throw them upward over the spot where the firing takes place, and finally with their own motion to bring them together. A spiral motion would result from their union; larger and larger portions of the two currents would become involved in the change; the two bodies of air would become mixed, and the conditions required by the Huttonian theory of rain would be fulfilled.

Another way in which it may be supposed that heavy concussions often repeated act to cause a current of air saturated with vapor to rise and mix with a current above, remains to be considered. It is frequently the case that the first phenomenon following a battle is a dense fog. I have given but little prominence to this circumstance in the foregoing statement of facts, but it seems to show that concussion may operate directly to cause condensation of aqueous vapor, for fog results from condensation of a portion of the invisible vapor in the atmosphere into drops large enough to be seen. If concussion, by forcing particles of aqueous vapor together, condenses even a very little of the vapor contained in an air current, it may in so doing change very materially the conditions governing

the motion of such current. By the condensation of a little vapor some heat would be evolved throughout that portion of the current in which the condensation took place. This heat would rarify, though ever so little, that part of the current, and give it a tendency to rise. This effort to rise would cause some of it to mix with the colder current above. In this way a circular motion would be started and a process initiated which would gather strength and volume by its own action. For, when the two currents began to mix, the mixing would cause condensation of more vapor and thus would cause the setting free of more latent heat, and the setting free of more heat would cause greater rarifaction of the air and a stronger tendency to rise, and thus the process would go on at a constantly accelerating rate of progress until vast volumes of air would become involved in the new motion and rain-clouds be formed.

So far as our knowledge of this subject extends, when cannon firing brings rain it generally brings it at the place where the firing takes place. It may seem at first glance that there would be a difficulty in reconciling this fact with the existence of a moving stratum of air in which most of the vapor is brought which makes the rain. It would seem as though the centre of the storm

would be far east of the place where the circular motion was initiated by the time the storm had fully developed. It may, indeed, be possible that this is so, and that the place of firing will be found to be always in the western part of the storm area. Still, it would not be a violation of reason nor of probability to suppose that the storm centre remains stationary over the place where the firing takes place until the storm is fully established. At the commencement, the new action set up would be confined to the upper stratum of the lower current and the lower stratum of the upper current. These, mingling together, would set up a rotary motion, but as a whole, the air partaking of this motion would perhaps move neither very far east nor very far west, being acted on by opposing forces, one tending to carry it eastward and the other westward. When, however, large enough volumes of air become involved in the motion to produce rain, the storm will move eastward along with the warm current; while the air which has yielded up its vapor will probably be added partly to the cold current, above, and partly to the surface air below.

There has occurred to me still another and an entirely different explanation of the possible manner in which cannon firing acts to bring rain, and I

will here give it. As before stated, it has been established by the observations of the Signal Corps that all our storms except those moving up the coast from the Gulf of Mexico move across the country from west to east. There is seldom a time when there is not a storm thus in motion. Sometimes the storm is moving across the northern part of the country, sometimes across the middle part, sometimes across the southern part, and sometimes across the country from southwest to northeast. Sometimes there are two or more storms in progress at the same time. Sometimes several storms move in succession across the same part of the country, causing an excessive amount of rain in that section; while, at the same time, some other part of the country has no rain and suffers from a drouth. Now it may be possible that a spell of heavy cannon firing, instead of initiating a new storm as I believe it to do, may simply draw to the place where the firing takes place, a storm already in motion somewhere to the westward. If this should prove to be the true explanation, which, however, I very much doubt, we must still look for the reason of it in the action of concussion upon air currents; for concussion is a shock whose effects must extend to the extreme limits of our atmosphere unless its force is expended in the condensation of vapor—though this force diminishes in pro-

portion to the square of the distance from its initial point. If to divert storms from their natural courses should be found to be the limit of our control of the rainfall, even that measure of power would be of immense value to the country if properly utilized; for by it we could secure a more uniform distribution of the rainfall and prevent any one portion of the country from receiving an excessive amount while another portion was suffering from the lack of it. The good to be derived from such a regulation of the rainfall, however, would come principally to the states east of the Mississippi River. There is far more of hope for the western portions of Kansas, Nebraska and the Dakotas and for the arid regions beyond in the theory that a new storm can always be produced and that it will be heaviest at the place where it is originated.

The question, however, as to whether rain can at all times be produced and whether or not it can be made to pay can only be settled by means of experiments. In conducting these experiments the object ought not to be at the first to see with how small an expenditure of money or of powder a rain storm can be produced, but the great aim in the first experiment ought to be to make it a success if success is possible. Let us first demonstrate that we can make it rain—after that, let us

seek for the most economical way to do so. Possibly it will be found in the use of dynamite exploded in the midst of the equatorial current itself. But if we should commence with a small experiment there is danger of failure, and this would give occasion to many who do not understand the principles involved to cast ridicule on the project, and might lead to its abandonment. But with success attending the first experiment, however great the expense of it may have been, the country would view with approval such further experiments as might be necessary to bring the system to a practical working basis.

In order to eliminate as far as possible the chances of failure in our first experiment, we ought to take advantage of the experience gained in our late war in making it rain when far different objects were had in view. If we do this we shall not be sparing of our powder nor in the number of cannon employed. We shall place our guns in two lines about as far apart as we should be likely to do if engaged in actual battle, the guns in each line pointing towards the other and somewhat elevated, and fire them as rapidly as the safety of the gunners will admit of for, say about seven hours, in one day—first for three hours, then, after an intermission of three hours, for four hours longer. I would propose to keep up, for so

many hours this uproar on the earth and in the heavens, not because I believe it would ordinarily be necessary to do so in order to bring rain, but because it might possibly be so at the time and in the place selected for the experiment. In order to produce the heaviest possible concussions we should, during a portion of our firing, connect all our guns together with an insulated wire, and fire them simultaneously by means of electricity. Though I believe that this manner of firing would be the most effective of any, I would limit it on our first trial, lest we depart too far from the way in which we have reason to believe that rain has been produced before.

An idea awaiting verification or disproval is that a spell of rapid firing, followed in a few hours by another a little longer continued, will produce the greatest effect with the least amount of powder. Among the things noticed in a study of the meteorological records in the log books of the navy, is that the sky sometimes becomes overcast after a naval battle, then clears off, and then becomes overcast a second time, before it rains, and all within a short space of time. Another is that the barometer will sometimes fluctuate during a battle, and that sometimes it rains after the second fall of the mercury. The first noticeable movement of the mercury in the barometer after the commencement of a battle

seems sometimes to be a slight rise. The movements of the barometric column during battles, however, are frequently so irregular, owing doubtless to other causes than the firing, that they seem to have but very little value in adding to our knowledge of the specific effect upon the atmosphere of the firing.

The change in the height of the barometer caused by an ordinary naval battle, is generally not very great, seldom exceeding two-tenths of an inch. At the bombardment and passage of the Vicksburg batteries by Admiral Farragut on the morning of June 28, 1862, the movement of the barometric column was much less, even, than this. But after the naval action off Charleston January 31, 1863, there was a fall in the barometer of nearly half an inch.

I will remark here that it is not the diminished pressure of the atmosphere, as shown by a fall in the barometer, that brings rain. On the contrary—aside from such causes for barometric fluctuations as the winds and the tides in the atmosphere—it is the rain, together with the motion of the air in which it occurs, that causes the diminished pressure or area of low barometer. The mingling of the equatorial and polar currents, the condensation of vapor, the release of latent heat and the circular motion are, together, the causes that diminish the weight of the

atmosphere within the storm area and in front of it, and cause the mercury in the barometer to fall.

Returning to the question as to why artillery firing does not always bring rain, I will remark that the great reason, and the one that overshadows all the rest is, that it is not always that enough guns are brought into action and fired simultaneously, or if fired together, that this kind of firing is not long enough continued. There may be minor reasons, also, having reference to the arrangement of the guns, to the continuity of the firing, and to the intervals between different spells of firing. All these would need to be understood in order to produce the greatest amount of rain by the least expenditure of powder. But in a great battle there is such a large amount of firing, so many simultaneous shots, such a diversity in the arrangement of the guns, and such a continuity in the noise—concussion following concussion—that it generally happens that all the conditions necessary to bring rain in large quantities are fulfilled. In order to understand why very heavy concussions would produce an effect, while lighter ones might produce none, let us consider what concussion is. To get an idea of it, suppose a number of billiard balls to be laid in a straight row, the contiguous balls touching each other, and suppose the ball at one end of the row to be struck in the direction in the line of the row. The first

ball receiving the blow will transmit it to the next, this to the third, and so on. In the same way, in concussion, the atoms and molecules composing the atmosphere strike each other, the motion being in straight lines in every direction from the point where the shock originates. In the case of the billiard balls, the harder the blow the farther will the ball at the extreme end of the row fly from the others, and the greater the pressure on the intermediate balls. So, in the case of the atoms and molecules of the atmosphere, the harder the blow of concussion the greater the pressure at those points where its action is effective. Hence, while the concussion of a single shot, no matter how often repeated, may not affect the aqueous vapor in the equatorial current, yet the greater blows struck by many cannon being fired at once may produce an effect upon it which would astonish us if we could see what actually takes place. For further illustration, let us suppose, in the case of the row of balls, that instead of all of them being elastic, there were two balls lying adjacent in the row which were made of thin glass and filled with water; the blow on the first ball in the row would shatter these two, and the water in them would run together. Whether or not the blow would proceed farther would depend upon its initial force. Suppose, similarly, that in a row of molecules reaching from the cannon's

mouth into the heavens there were two molecules of aqueous vapor adjacent to each other, would not a heavy shock of concussion shatter the envelopes of heat by which they were surrounded, and cause the two to unite into one particle? And if there were many molecules of vapor lying on such lines, would not the number of such condensations depend upon the force of the shock? A portion of the latent heat belonging to the molecules so united would thus become free. Suppose this took place in the body of the equatorial current. It would be a virtual transmission of force from the cannon's mouth into that current. Enough condensations of this kind would destroy the equilibrium of that current, in the manner described on page 96. But we must have concussions heavy enough to strike the requisite blows, or they will produce no effect.

Again, in those very rare cases in which it is claimed and cannot be shown otherwise that battles were not followed soon by rain, it may be that there was much more artillery on one side than on the other. While it cannot in the present state of our knowledge on the subject be shown that the meeting of opposing shocks of concussion is a necessary element in bringing rain in this way, yet it is fair to surmise that it may in some way add to the energy of the upward force. It may be,

also, that, except in very favorable circumstances and when the first firing is exceedingly sharp and concentrated, it is requisite that, after a few hours, a second impulse should be given by a second spell of firing.

These considerations, I think, will show that it would be illogical to reject the whole theory and refuse to put it to the test of experiment because there may have been some instances of tolerably sharp artillery firing which were not followed by rain. If the circumstances connected with such could be fully known it would doubtless appear that, if the firing was heavy, it was very short. There have been days and weeks of artillery skirmishing which brought no heavy rain though it sometimes brought showers. That it did no more furnishes no argument against the theory under consideration. The force that, if concentrated, would have brought heavy rain was too long drawn out—it was dissipated and went to waste. I opine that but a very poor argument could be made out against my theory by an examination of cases where battle or artillery firing was not followed by rain. I do not know of a single really great battle of which this can be said and proved. If any one of my readers who took part in our late war should think he remembers such, let him look over my list of battles followed by rain and

see if it is not there, and if there let him balance the evidence I furnish against his own recollections or the want of them. And if he thinks he remembers even artillery skirmishes which were not followed by rain, let him take warning from the rash utterance of one of my correspondents who, in speaking of such skirmishes in the Shenandoah Valley in August and September, 1864, which he dignifies by the name of "daily battles," declares that they were accompanied by an "unusual drouth," and deduces thence an argument against my theory; while I am able to show by an actual record that there were ten rainy days in that region included in less than one half of the period mentioned.* Now in saying this I do not question the general accuracy of my correspondent's statement. I admit that there was a drouth; I admit that the ten rains did not break up that drouth; and my conclusion is that, while artillery skirmishing will sometimes bring showers, it requires heavier firing to bring long continued and soaking rains.

The author has, on two occasions, memorialized Congress on the subject of experiments. In his first petition he referred mainly to the facts, and in his second, to the philosophy bearing on the subject. This latter petition was presented through

* Nos. 17 and 18 of Appendix.

Hon. C. B. Farwell, of Illinois, on February 28, 1874, and was as follows:

To the Honorable the House of Representatives of the United States:

Your petitioner, two years ago, presented to your honorable body a memorial setting forth certain facts going to show that the discharge of artillery in heavy batteries, continued for a few hours, will bring rain in large quantities; and asking that an experiment might be performed with powder and cannon of the United States to determine if drouths cannot in this way be prevented. He now renews his petition for such experiments, and begs leave to present some facts of a different kind from those before stated, which tend to add to the credibility of his theory.

In a work of that distinguished investigator of natural phenomena, the late M. F. Maury, on the "Physical Geography of the Sea," it is claimed that the principal portion of the aqueous vapor that forms the rain that falls within the United States is brought by atmospheric currents from the Pacific Ocean. It is contended that the great southeast trade wind of the Pacific, which meets the northeast trade wind near the equator, after rising there, flows over that trade wind to the belt of calms near the tropic of Cancer,

where it descends and becomes a great southwest rain-bearing current across our continent; and that, above this current, is a great polar current flowing in nearly an opposite direction. The south-east trade wind of the Pacific which becomes thus a great vapor-bearing current above the United States, extends from the surface of the ocean to the height, it is supposed, of about three miles. It moves over the ocean for about two thousand miles, and with slight interruptions, it blows perpetually. The amount of vapor which it takes up is inconceivably great; for it is calculated that as much water is evaporated from the ocean in one year as would depress its whole surface eight or ten feet. It is true that much of the vapor that rises from the ocean falls back into it again afterwards, as rain, but the amount which is carried over the continents is immense, and vast quantities of it, transparent and invisible, must pass over the United States, to fall afterwards as rain or snow on the Atlantic Ocean, in Northern Europe and in the polar regions.

Now, the deductions of Maury in relation to winds and air currents, made from thousands of observations taken in all parts of the world, seem to be confirmed so far as the existence of a rain-bearing current over this continent is concerned, by the observations of the Signal Corps of the United

States Army; for it is found that nearly all our principal storms come from the westward and southwestward; and this, as Maury shows, will be the course naturally taken by the air of the southeast trade wind when it becomes an atmospheric current in the Northern Hemisphere. The observations of aëronauts also add confirmation to his theory, for they declare that they have found an eastward current which they believe to be constant.

Your petitioner, therefore, respectfully represents that these facts give reason to believe that there are, at all times, vast quantities of aqueous vapor passing over us from the Pacific Ocean; that the existence of an extremely cold current above the vapor-bearing current gives reason to believe that the conditions necessary to produce rain in the manner in which we are taught by the Huttonian theory it usually is produced, are always present, and that the occurrence of heavy rains after battles gives reason to believe, not only that such conditions always exist, but that the process by which clouds and rain are formed from the invisible vapor can, at any time, be set in motion.

And your petitioner further represents that, while the observations of the Signal Corps show that on an average as many as nine storms traverse our country from west to east in a single month, these storms are yet so unequally distributed that some

portions of the country suffer at times from terrible drouths, while others are drenched with excessive rains; and that, if it should be found that there is in the effects of heavy concussions a power such as to cause storm centres to deviate from their natural courses, a system for distributing the rainfall can be worked out which, by leading to the prevention of forest fires and by adding to our agricultural resources, will be of inestimable value to the country.

[Signed] EDWARD POWERS.

Let us now proceed to discuss some of the objections to the theory under consideration. It might appear from the letters published in the Appendix that the opinion became general in our army, during our late war, that artillery firing brought rain. Such, however, was not the case, as there were a vast number who gave no thought to the subject and there are some who, when their attention was afterwards called to it, expressed doubt that this effect was ever produced. The few, however, who, in correspondence with the author, have expressed such doubt, generally base their opinion on what can be shown to be unsound premises. If, in speaking from memory, they say of such or such a battle that it was *not* followed by rain, it can generally be shown by affirmative

evidence that their memory is at fault. Objections of this kind it would be useless for me to quote here for the purpose of controverting; as my facts are elsewhere presented, and the evidence by which they are supported is either given or referred to in such a way that it can be found by any seeker after the truth.

Gen. J. H. Wilson, of the United States Engineers, who is one of the doubters, treats the subject very fairly when he says: "I am constrained to say that my experience, extending from the first to the last days of our late war, during which I participated in nearly all our great battles, does not justify me in pronouncing an opinion favorable to your hypothesis in reference to the influence of cannon firing in producing rain. I should add, however, that I have given but little attention to the subject, and, therefore, do not wish to be understood as saying that you are incorrect in your suppositions. The question, although not a new one, is, as you justly remark, one of great interest, and should be settled by experiments directed solely to that end. I do not regard the casual recollections of officers in reference to such a matter as of any great value. A well directed series of experiments would be of infinitely more service towards the formation of true opinions. Trusting that your investigations

may be so encouraged as to enable you to arrive at the truth, whatever it may be, I am, etc."

Col. C. H. Crane, Assistant Surgeon General United States Army, says: "If it could be shown that rains were decidedly more frequent immediately after battles than antecedent probability would lead us to expect—that is, for instance, if the day after a great battle was rainy in sixty cases out of a hundred, while the average probability of a rainy day, in the places where the battles were fought, was only twenty per cent.—it would then remain to be inquired into whether battles were not commonly preceded by a number of days of dry weather that made military movements more active and brought the armies together."

The sixty cases in one hundred supposed above are very far short of the real number; but letting that pass, I will say that if it were true that battles are generally preceded by several days of dry weather, this circumstance would be rightly regarded by most persons as furnishing an argument for the theory that maintains that the battles cause the succeeding rains, rather than one against it. At any given time during a spell of dry settled weather, it is more reasonable to expect that the next day will be fair than that it will be rainy. If rains naturally occurred at regular intervals, then, in considering whether a rain following a battle was or was not

produced by the battle, it would be necessary to inquire whether it was not the time for rain, though there had been no artificial cause to produce it—but, occurring at irregular intervals as they do, this point would seem to be one which has no material bearing on the question. This will be more apparent, if we consider how it would affect the credibility of the theory if it could be shown that battles were generally preceded by wet weather, instead of dry. Indeed, in the case of two or three battles, it has been mentioned as a fact bearing against it, that they were preceded, as well as followed by rain. Thus it is seen that while one individual would doubt that a battle caused the rain which followed it, because there had been previous dry weather, and it was time to expect rain, another would entertain the same doubt in reference to another battle because there had been rain immediately previous and it was reasonable to expect more. Such reasoning requires only to be stated to show its fallacy. From the mere fact of dry or wet weather before a battle, it cannot be predicated what should be the weather which follows it.

An officer, whose name is withheld for the reason that his letter has been mislaid, says: "The difficulty is this: to cause rain by concussion of the atmosphere, you must have the atmosphere charged with

aqueous matter—a thing beyond your control. Therefore, while I believe that when charged with moisture, violent and protracted concussion may precipitate and hasten the fall of rain, I doubt whether, in the absence of a proper hygrometrical condition (which is always the case in times of drouth), any concussion would produce rain."

If the world had learned nothing in relation to the atmosphere since the days of Espy, the above would be a strong argument against the practicability of producing rain by cannonading in a time of drouth. But in view of the researches of Prof. Maury to which reference has been made, it may be said to have no force whatever. We do not get our rains from the surface atmosphere, and it makes but the slightest difference whether that atmosphere is dry or moist. Our rains, as before stated, are supplied by the Pacific Ocean, and the vapor is brought to us by the equatorial current of the atmosphere. If any one doubts this, let him read Maury's "Physical Geography of the Sea." He will find the fact proved therein as conclusively as it is possible to prove anything in regard to nature that we cannot see with our visual organs. Indeed, no sane man would say that the rivers could forever pour their waters into the sea without the sea giving them back to the land. These waters, in our own country, run principally into the Atlantic; but which ocean gives

them back? Maury says it is the Pacific, and he adduces the strongest evidence in support of his theory. How, then, do they come? Will it be said that the vapor comes diffused uniformly through the whole body of the atmosphere? If that were so, then California, being nearest the source, would be the dampest state in the Union. But this is not so; on the contrary, California has the dryest air of any except, perhaps, Colorado and other mountain states. The air of California is but little affected by its proximity to the ocean. Even on the very sea shore it is not so moist as in the Mississippi Valley. And why is the air dry in California and Colorado, while it is damp in the Mississippi Valley and in the eastern states? It is because the equatorial current does not, as a rule, discharge its waters upon those states except during a certain season of the year. It passes over them, and begins to precipitate its vapors after passing the mountains. It is not the moisture of the surface air east of the mountains that causes the rains; it is the rains that cause the moisture. California and Colorado might, perhaps, become moist, damp states if the air-currents passing over them were shaken up so as to cause frequent rains during the summer. This, however, might not be desirable. Those states might prefer to retain their character as great sanitariums for the cure of pulmonary complaints, rather than gain the advantage

to agriculture which frequent summer rains would give.

But some reader may say, "So distinguished a scientist as Prof. Benjamin Silliman, a letter from whom you publish, takes the ground, inferentially, that rains come from the ordinary atmosphere such as we have at the earth's surface. He does not believe that any amount of cannonading would bring rain from the dry air of Arizona, and he ignores the existence of any special air-currents charged with vapor." To this it may be said that it was twenty years ago that Prof. Silliman wrote the letter referred to, and that he simply held to some of the old ideas taught by Hutton and Espy. Meteorology, at that time, had probably been more neglected than any other science. His letter is valuable for the support it gives to my proposal for experiments, but not for any light which it throws upon the subject under discussion. But the time is coming when scientists will recognize the truth before stated, that it is not the moisture in the surface air of any country, not even excepting those lying within the tropics, that causes the rains in that country, but on the contrary, it is the rains that cause the moisture, by furnishing water for evaporation from the land and from the lakes and rivers to which they give rise and which they supply. To hold otherwise, as many have done, is to place effect for cause and

cause for effect—a thing of which this is not the only instance to be found in the treatment which meteorological questions have received.

I will add that, while no cannonading will bring rain out of the dry surface air of Arizona, it undoubtedly has brought rain from humid currents flowing over a stratum of air as dry as that of Arizona, as instanced in the rains that fell in Mexico after so many of the battles of our war with that country.

Before dismissing this part of our subject, it may be well to consider a little further the effect of rains and of drouths on the lower atmosphere. We all know that during and immediately after a spell of rainy weather the air is full of moisture. This is owing to the great evaporation made possible by the presence of so much water on the ground or falling as rain-drops through the air. During a spell of drouth, on the other hand, the air is dry. What has become of the water which evaporated; and why is not the air at the earth's surface as moist as during the time when the evaporation was the greatest? It is because a large portion of the invisible vapor, warmed by the heat of the sun, has risen to a higher altitude. This is the reason why the vapor brought to the coast of California by the surface winds from the Pacific is perceptible but for a short distance inland in that state. It sometimes

condenses into fogs along the coast, but the morning sun dissipates them, and returns the vapor to its invisible form, and it rises and passes over the state at such an elevation that the surface air remains dry. Here is an important point, and it is amazing that the meteorologists do not seem to have recognized it. When water evaporates, it hastens to rise—to work its way upward between the gaseous atoms of the atmosphere. Cloudy weather retards its rise, bright sunshine hastens it. The longer the sunshine continues with absence of rain, the more the surface air divests itself of its moisture. It is true it cannot part with all its vapor, even in a desert where it never rains; for there is a point where it can get no lower in moisture, owing to the circulation of the atmosphere which brings in some vapor from afar. But in a country like ours, the longer a drouth has continued, the greater the amount of vapor which has risen to those regions where it must be in order to take any part in the production of rain.

But what further becomes of the water which evaporates from the earth and ocean in the temperate and frigid zones? It falls as rain; but in order that it may do so, there must be a rainstorm formed by the mingling of portions of the equatorial and polar currents. When this takes place, the upper portion of the surface air is drawn into the motion as has been before stated, and the vapor which it contains helps to make the rain.

I am aware that in giving this explanation of the way in which the evaporation in our latitudes adds to the rain, I am differing from some high scientific authority. Elysée Reclus, an eminent French savant, holds that raindrops, in passing through the air, pick up the aqueous vapor and add it to themselves. He says in his work entitled, "The Ocean, Atmosphere and Life," speaking of raindrops, "In traversing the atmospheric strata saturated with moisture, each drop enlarges itself on the way by other scattered droplets, and continually brings back to the earth the pluvial moisture which has evaporated." He gives a reason for this theory, but admits that the fact on which he founds it is not conclusive evidence, for he proceeds to explain his fact in a different way. In my view he is wholly at fault in what I have quoted; for I believe it more true to what we know of evaporation in general, to hold that the rain-drops themselves evaporate to some extent in falling, and leave more moisture in the lower stratum of the atmosphere than there was before the rain.

But I have no fault to find with Monsieur Reclus' philosophy, so far as it goes, in regard to the primary cause of rain in the temperate and frigid zones. He says: "Beyond the equatorial zone most of the showers are, so to speak, not formed on the spot by the condensation of ascending vapors, but are brought from afar by the currents of the

atmosphere." Equally true is it that even in the equatorial zone most of the vapor that forms the showers that fall on the land is brought by atmospheric currents from the ocean.

Considering further the objections to my theory, I note that there is a class of critics, happily few in number, who approach the subject without any intention to treat it with judicial fairness, and without any desire to find in it the germs of a truth worthy of investigation and development. Starting out with a predetermination to write it down, they seek to belittle or ignore the strong points of the argument, while they make the most of the weaker ones, and misrepresent it in every possible way. Conspicuous among such was the critic of the *Nation*, a weekly paper published in New York, when, nineteen years ago, the first edition of this book was published. The newspaper referred to had at that time a style of criticism—as was remarked of it later—whose principle seemed to be that of the then editor's countryman at the famous fair, "Wherever you see a head, hit it." Here is an example of the fairness of that paper's critic. In pretending to give a specimen of my facts, he selected an inconsequential circumstance taken from Gen. Heintzelman's journal headed, "Artillery firing in front of Hooker," and which, as he could scarcely have failed to see, was given place in the book, not from its supposed

importance, but from its connection with other matter. Why were not some of the great battles or the bombardments of forts or shore batteries which were followed by great rains mentioned instead of this? In the light of what I have said the answer is obvious.

Again, in pointing out a better way for investigating or presenting the subject than the author had adopted, he said: "Mr. Powers should have confined himself to a narrow space and time, and given the weather record for every hour during the period selected." If he refers to battles on land, it passes comprehension how any man in his senses should think it possible to give such precise data when no such records were taken within hundreds of miles of the scene of hostilities, except at such times as a gunboat or ship of war happened to be in the vicinity. For the author to have confined himself to what was recorded by one gunboat or one fleet while operating in any one place, would certainly have been to confine himself to a sufficiently "narrow space and time"—so narrow, indeed, that he would have been exposed to far juster criticisms from men of right feeling and good sense than any to be found in the screed of the *Nation*.

This critic finds fault, also, with the order in which the battles are arranged. It may be said on this point, that so far as the battles of our late war are

concerned, the order is generally the same as that in which they are arranged in Greeley's "American Conflict"—an order much more suitable to the purpose than would be one more exactly chronological, as by it the different campaigns of the different armies are each separately considered, as are also the different series of operations by ships of war and gunboats against forts and shore batteries on the Mississippi River and on the Atlantic and Gulf coast. But it is of the arrangement of certain battles, etc., taken from Espy's "Philosophy of Storms," that he has most to say. It amuses him to find that "after a battle in Prussia in this century is mentioned a salute fired in Madras in 1776, then the siege of Valenciennes in the French Revolution, then the bombardment of a fort in Sweden," etc. But though he considers this arrangement as reckless, he does not show how any different arrangement could have added any force to the evidence given by the facts stated. Espy no doubt was wrong in believing that the heat of the burning gunpowder was what caused the rains after the battles he mentions; but he made no serious mistake in his arrangement of them, and it would be puerile to claim that any weakness attaches to his argument on account of it. Equally nonsensical is it to claim that any such attaches to mine in following it.

Our critic also says: "Irrelevant matters are ad-

mitted, such as names of generals, military manœuvres, numbers killed, compliments to troops (to the Russian infantry at Eylau)!" Some of these, it is needless to say, were directly relevant, our critic to the contrary notwithstanding, being explanatory to the nature of engagements referred to as producing rain. And as to the compliments to the Russian infantry at Eylau, if he had added that the passage in which he found them was a quotation from "Scott's Napoleon," while the occurrence of snow was the central idea brought forward, his article would have contained one less instance of what was, practically, misrepresentation.

He goes on and says: "Why does it never occur to the author to tell the calibre of the heaviest guns used in a given case, or whether the sky looked like rain before the first discharge?" The calibre of the heaviest guns! If it were possible to obtain this information, of what use would it be in a preliminary exposition of the subject? Of what use would it be even as a guide in performing an experiment, unless we knew how many of them were used, and how many times each was fired? Twenty pounders, or even twelve pounders, will bring rain as well as one hundred pounders, if enough of them are employed. And the implication that the author had never told whether the sky looked like rain before the first discharge shows, either that our critic

had not read the book, or that his inclination to misrepresent was uncontrollable. There are at least thirty cases in the book where the state of the weather or the appearance of the sky before the action is mentioned. In the Appendix to the first edition, also, there were printed twenty pages of meteorological records taken from the log books of various ships and gunboats, and which gave, among other information, precisely the kind which he demanded, but which tables he was so inconsistent, and at the same time so saturated with malice or so destitute of ordinary common sense, as to pronounce "worthless because disconnected." They are omitted from this edition of the book, not because of his opinion of them, but because the essential facts which they contain are elsewhere stated, and because it is probable that but few readers would take the trouble to study them, as most certainly did not the critic who complained of a lack of information as to "whether the sky looked like rain before the first discharge." By the wild and reckless manner in which he flourished his shillaleh in this instance, he would seem, so to speak, to have delivered a blow on his own head.

Continuing, he asked, "Why is it that only five of Bonaparte's battles are alluded to? Were all the rest followed by fair weather?" As others may ask the same question, I answer, I do not know. Many

things have happened in the world of which history has preserved no record. Possibly records may somewhere exist which would reveal what the weather was after each and every one of Bonaparte's battles, but I have made no extended search for them, nor have I thought the knowledge indispensable.

The *American Journal of Science*, in its criticism of the book, said: "He takes no account of the cases unfavorable to his theory, in which rain follows a battle only after a very long interval." There is reason enough for this. There may have been some small battles and smart artillery skirmishes which were not followed by rain, but I do not believe that there was ever a great battle in which much artillery was used, that did not produce it. If, for want of records, this sequence cannot be shown of all the great battles of modern times, no one is justified thereby in declaring a negative.

The journal referred to wholly passes over the main idea for which I have sought to gain adherents—namely, that a series of experiments in the matter ought to be made with such aids as only a government can supply. It also brings into the discussion what is, substantially, a misstatement of fact—viz.: that, throughout the region from which my examples are mostly collected, rain falls upon an average, once in three days. Now, whatever

may be the average number of rainy days in a year, counting all those on which there is a mere sprinkle, it certainly is not true that we have, with this degree of frequency, such rains as those which follow great battles. If this were so we should be in the midst of a continued deluge; and in view of the terrible drouths that so often afflict the country it is the veriest trifling to oppose such an argument against the theory under discussion.

This journal was also kind enough to point out what it considered would be the "truly scientific" mode of examining this subject; but the method it recommended would be totally impracticable for the reason that a sufficient amount of the data that would be required has never been recorded and does not exist. It proposed, in effect, that the fact of rain following soon after battles should be rejected as not having any bearing on the question, and that no conclusion should be allowed except what could be drawn from a comparison of the average intervals between the end of one rain and the beginning of the next—the average interval between the conclusion of a rain next preceding a battle and the one next following it being compared with the average interval between two successive rains when no battle had occurred.

Now, as rains occur at exceedingly irregular intervals and as the number varies for different years, it would require many years of war to enable a comparison to be reached in this manner that could be relied on. It would also require that all the battles that were taken into account should be fought in one place, and that a careful meteorological record should be kept at that place during the years in which they were fought and also during an equal number of years preceding or subsequent thereto. But taking things as we find them, and considering that the battles of our late war were fought at different places over a vast extent of country and that no meteorological records were kept except by the navy, the suggestion that the subject should be examined in this manner is simply absurd. The manner in which I have proposed that it should be examined—that is by experiments—this paper probably does not think would be scientific, as it did not allude to it.

It was denied by implication that I had shown that artillery firing had ever caused rain, but no attempt was made to explain on any other hypothesis any of the striking facts brought forward, as for instance why it rained during the battle of Buena Vista fought in Mexico during the dry season, or why it rained at Madras on the 4th day of June, 1776,

after the firing of salutes, though this was in the dry season on the Coromandel coast. It is true that such examples do not prove with the force of a mathematical demonstration that rain can be produced by human agency, but they give ample ground for the assertion with which I set out, that there is the strongest reason for believing such to be the fact.

While denying that I had established my proposition in a satisfactory manner the writer of the criticism referred to was inconsistent enough to admit that he was "inclined to the opinion that great battles do exert some influence in the production of rain." And how, may I ask, did he arrive at such an opinion? Was it by any such process as that which he pointed out as the proper method to be adopted in examining the subject? Was it not from the simple statement of facts and sequences such as I have detailed in this book, and from the further knowledge that intelligent men who had witnessed the phenomena referred to, believed that battles caused rain? If then, for such reasons he was inclined to this opinion and would even "be pleased if Mr. Powers or some other person would resume the discussion" with data such as only another and a longer war could supply, it is a little remarkable that he should have been unwilling that others should form an opinion on the

same kind of evidence as that which influenced his own mind.

Evidently the journal referred to was satisfied that it had shown that there was nothing of consequence in the book, and that, after its exposition of the same, none of its readers would care to see it for themselves; for it omitted the customary notice of its place of publication. Claiming to be specially devoted to science, it showed both in what it said and in what it neglected to say—and especially in wholly ignoring my argument for the only common-sense and practical way by which the question in consideration could be determined—that it was animated by the same hostility to anything new that has characterized, as a class, those claiming to be the special devotees and exponents of science in all times.

Turning now to a point which, if not directly belonging to our subject is connected with it in some degree, as is everything relating to the motions and states of the atmosphere, let us consider for a moment the nature of cold waves, their cause and motion. It is the more important that we should glance at this subject, for the reason that theories should always be consistent with known facts and that our theory of the artificial production of rain, as developed in this book, has for one of its main supports the alleged fact of the exist-

ence of the equatorial and polar currents and that the polar current is above the equatorial and moves toward the southwest. It may be asked how this fact can agree with the fact that we have cold waves coming down from the northwest. It may be answered that the agreement between the two is perfect if we assume that a cold wave is caused by the polar current breaking through the equatorial and making an irruption into the atmosphere below it. Far to the north the equatorial current must be thinner than in our own latitudes and more liable to be divided up into streaks or separate streams. Between these, portions of the polar current forces its way and pours floods of cold air into the lower atmosphere. Now the lower atmosphere has the same general motion as the equatorial current, being carried along with it—that is, to the eastward and northeastward. The air from the polar current meeting it can no longer continue on its former southwest course, but must take a course which will be the resultant of the two forces acting on it, and this course will be towards the southeast. But it may be asked, "Why, then, should not storms also travel from northwest to southeast?" Because the equatorial is so much stronger than the polar current, and because so much larger portions of the former than of the latter are involved. But undoubtedly the motion of storms is less to the north-

ward and more directly to the eastward than that of the equatorial current.

There is a possible objection that might be offered to the proposed experiments for bringing rain storms artificially in that they might work damage as well as confer benefit. It might be said, "Suppose you try an experiment for the production of rain and you overdo the business, so that instead of refreshing showers you have deluges. Suppose the creeks rise—that buildings are washed away—that men, women and children are drowned, that lightning strikes houses and kills the inmates, that it strikes barns and the farmer's gathered crops are burned and his stock killed, and worse than all, suppose that cyclones are generated that reach down and destroy all within their path! Would your interference with the workings of nature then be a blessing to humanity? And who will pay for the damage done? If Congress appropriates money for the experiment will Congress make another appropriation to reimburse the losses?" It is a good reason why Congress rather than private individuals should undertake these experiments, that if there should be any damage done the injured parties would know where to look for redress. There are many public-spirited and philanthropic men of wealth numbered among our citizens to whom the cost of a few such experiments would not be felt,

and one of whom, perhaps, could be persuaded to undertake them, were it not for such considerations as the above. But if one such should furnish the means for such experiments, would he not be liable to be harassed by lawsuits by parties who would claim that they had been damaged thereby if rain should result? True, the lawyers could not cite any statute forbidding an individual to make it rain and they might search in vain in the reports of the Supreme Court decisions of all the states and of the United States for a precedent for mulcting a man in damages for having done so. A new question in jurisprudence might thus arise; but in spite of the absence of precedents it might be that the defendant could escape only by denying that he did make it rain and defying the plaintiff to prove that he did—thus stultifying himself in a manner that would be highly inconsistent with an earnest desire to advance useful knowledge and scientific truth. But some one may ask, "If it should rain heavily soon after the experiment, would it not be easy to prove that the experiment caused the rain? Do you not claim that you have proved that battles cause rain?" No, I do not claim that I have proved it by evidence that would be satisfactory in a court of law; I only claim that I have shown it to be extremely probable. The truth of the theory can only be demonstrated by

predicted results, and it would require many such to make the demonstration such as would fill the requirements of legal evidence.

But, seriously, so far from storms brought on artificially being likely to prove unusually dangerous, they will be, I believe, in one respect at least, the very means of averting danger. Though the rain that follows battles often comes in torrents and deluges, yet the copiousness of the fall simply shows the abundance of the vapor from which it is drawn; while the general rule that the heavier the firing the greater the rain indicates that there is, underlying it, a principle that needs only to be understood to enable us to procure rain in greater or less quantities as may be desired. Though thunder and lightning often accompany such rains, yet we are liable to have these with our rains however produced, and it would be folly to refuse the boon of showers because of such accompaniments. And though there are sometimes squalls of wind, yet these are not a source of serious danger. Battles have never produced tornadoes; on the contrary there is reason to believe that battles have produced a state of weather unfavorable to their occurrence. Was there a single tornado in the United States during our four years of war? Can it not be said, at least, that our country was unusually free from them at that time? If so, may we not fairly anticipate that an

occasional rain-storm brought on by cannon firing will give a steadiness to the air-currents and keep them at such a height above the earth that tornadoes will be abolished? If cannon could be fired in the vicinity of a tornado at the instant it appears or at any time while on its destructive course, it would be broken up and the furious air-currents that produced it would recede into the heavens where they belong. Water-spouts at sea are precisely the same thing as tornadoes on the land, and the breaking up of them by cannon firing is a fact that does not seem to admit of dispute. But on land it would be impossible to have our cannon ready at all places to attack them whenever and wherever they might appear. Our safety lies in preventing them from forming. Probably with one station in each State supplied with cannon this could be done by simply producing a rain as often as the needs of vegetation might require. If that would not do, then the object could probably be accomplished by watching the sky for indications of danger, telegraphing these indications to the central station whenever they appeared at any place within the State, and firing at that station. I do not expect to find ready acceptance to this idea; it would be contrary to the experience of the world, if such should be given; the very mention of such a thing is enough to provoke shouts of derision in

some quarters; but I maintain that there is reason to hope that the prevention of tornadoes is not beyond the reach of human power, and that the bare possibility of it is an additional reason why all the possibilities for the control of the weather that lie in the use of powder and cannon should be worked out, and worked out without delay.

In this connection it may not be out of place to ask whence comes the terrific power of the tornado? It may be looked for, first, I think, in the inherent force of the two currents that unite to form it; and, secondly, in the heat and electricity loosened by the rapid condensation of aqueous vapor, the funnel-shaped, revolving cloud being the imperfect conductor that conveys the electricity to the earth. How the heat and electricity operate to intensify the whirling motion which the funnel-shaped cloud receives from its parent air-currents is a mystery; but we know that they are both forces and modes of motion. We also know that heat is given out by condensing vapor, and that heat is convertible into electricity. Those who, in attempting to explain this meteor, reject electricity as one of its chief factors, come far short of accounting for its tremendous power and its strange freaks; and those who ignore both the action of air-currents and of electricity fail to give an explanation which in any degree accounts for them.

What is called "Ferrel's Theory of Tornadoes" seems to have met with a good deal of favor, but to my mind it is very unsatisfactory. If I understand it correctly, it holds that the destructive force of the tornado resides in an inrushing surface blast that pours into the funnel-shaped cloud at its lower end and rushes up thorugh a vacuum in its centre; and that this rush of air is caused by atmospheric pressure. But how can atmospheric pressure develop the force exhibited by a tornado, seeing that it is only about fifteen pounds to the square inch?

This theory accounts also for the force of the whirl by seeking to apply the "law of the preservation of areas" to supposed indrawing masses of air moving in a circle. What is the "law of the preservation of areas," or, in other words, the "law of equal areas in equal times"? It may be explained, substantially, thus: Suppose one ties a leaden ball or other weight to the end of a string and fastens the other end of the string to a pencil, then, taking the pencil in his hand he whirls the ball around, letting the string wind up, meantime, on the pencil. Now, by the law of the conservation of areas, the string passes over equal areas in equal times; the ball moving enough faster as it approaches the pencil to compensate for the shortening of the string. In order to make this illustration strictly correct the ball should revolve around

a fixed point which should have no sensible thickness, and the string should be shortened in some other way than by wrapping around it. As applied to astronomy the law may be explained thus: If we suppose an imaginary line to be drawn from any planet to the sun, this line will pass over equal areas per second in whatever part of its orbit the planet may be. I will add for the information of the unlearned reader, for whom this explanation is intended, that the planets revolve around the sun in elliptical or elongated orbits, so that any planet is always either approaching nearer to the sun or moving farther away from it. Now, by the law of the conservation of areas, when a planet is moving away from the sun its velocity diminishes, and when it is moving towards the sun its velocity increases just enough to preserve the equality of the areas passed over per second by the imaginary line above mentioned. This is the law, as I have said, by which Ferrel's theory endeavors to account for the force of the whirl in tornadoes; but in claiming that the air in the whirl, or air approaching the whirl, obeys the same law as a solid body would obey if tied to the end of a string and whirled around, it makes a wholly unwarranted assumption. The law referred to does not apply to the case at all, seeing that the air in the whirl or air said to be approaching the whirl is neither

tied to the end of a string nor held from flying off on a tangent by a force of attraction such as keeps the planets in their orbits.

The theory referred to also holds that the vacuum which it claims to exist in the centre of the tornado is caused by the centrifugal force of the whirl, which throws the air away from the centre; but why it throws this air a certain distance from the centre without throwing it off on a tangent is not explained. But as the whole theory seems to hinge on the absurd assumption that these moving particles of air are governed by the same laws as those which hold the planets in their orbits, it cannot, of course, be thought that this point needs any explanation. Another point that seems to have escaped the attention of those who adhere to Ferrel's theory is this: Atmospheric pressure can raise water in a pump to the height of not over thirty-four feet; yet a tornado passing over a pond will draw the water from it and carry it to an immense height. There must be something different from atmospheric pressure to do this.

Prof. Davis, of Harvard College, who has adopted this theory, in a little book of which he is the author, entitled "Whirlwinds, Cyclones and Tornadoes," denies that there is any downward motion in the tornado—for to admit it would be fatal to the theory—and yet he tells of a timber four inches square being driven three and one-half feet into the ground, only

forty-five feet from its starting point! Surely this timber could not have been acted on by a furious *up*-rushing wind when thus forced into the ground, nor could it have penetrated to that depth from simply falling by its own weight after having been carried along only forty-five feet.

Prof. Davis appreciates the fact that a tornado is confined to clearly defined limits, and says: "At a little distance one side or the other there is not only no harm done, but there is no noticeable disturbance in the gentle winds." Yet he fails to see that this is wholly inconsistent with the doctrine that there is a furious in-rushing wind from outside the tornado into the centre.

These are not all the arguments that could be advanced to show the fallacy of the theory referred to, but they are enough.

I believe the truth to be that there is an upward motion in the centre and a downward motion on the outside of the funnel-shaped cloud, both motions being spiral or like the threads of a screw, and that this meteor is a machine worked by electricity and complete within itself. While some of the surrounding air with which it comes in contact may be drawn into it, it does not get from that air its motion nor force. And there is no more reason for denying that electricity is the motive force in this machine, in that we cannot understand its mode of action, than there

would be for a savage from the wilds of Africa to deny that an electric car was propelled by a force similar to that which he sees flashing through the storm cloud, because he could not understand how it was done. The untutored savage is no more ignorant in regard to the operation of the electric motor than is the most learned scientist in regard to the nature of electricity and its mode of action in some of its manifestations.

It may not be out of place to offer a few remarks in relation to the proposal to irrigate the Dakotas by means of artesian wells. It is claimed by some that these States are situated over an immense artesian basin, and that by boring numerous wells an abundant supply of water can be obtained. Now, while it may be true that there exists a supply of water sufficient to keep running a limited number of wells, it is exceedingly doubtful if this supply is sufficient to meet the wants of agriculture for any extensive district. In order that there may exist such a supply, two things are imperatively necessary: one is that the artesian basin must have its head in a region where there are abundant rains, and the other is that this region must be considerably higher than the region which is to be supplied with water from it. If the Dakotas are connected with such a region in the way referred to, it must be very far distant, and the more distant it is the higher it needs to be in order that the

flow of water may be adequate to the demands. So distant, indeed, must be the region where the artesian basin of the Dakotas has its head that it is more than likely that if a large number of wells were bored it would be quickly drained of the water that has accumulated in it. Hence it would be exceedingly risky for the people of these States to undertake extensive works of the kind referred to, for it might be in the end that the last condition of those States would be worse than the first—they might find themselves burdened with a heavy debt, while their irrigation works were useless. It is a mistake to assume in treating of this subject that what one well will do would be done by each one of a thousand, and to forget that in whatever way the earth is watered the source must be fed by rains or snows. The earth has no inexhaustible reservoir of water from which the Dakotas can be supplied, except the ocean. This is salt, and we do not want its waters through subterranean channels. We could not have them if we did, for they can come to us only through the medium of evaporation and precipitation. Let the Dakotas look first for these waters in the skies above them before entering into an extensive outlay to reach uncertain streams in the earth below them—streams which, if they exist at all, must bring their waters in slowly trickling currents from the distant mountains or from some high plateau in the unexplored

depths of British America. It is very much to be feared that if very many wells should be bored the principal gain would be to those who would furnish the machinery and do the work.

Judging from the letters which I have received since commencing in 1870 an attempt to bring forward the subject of rains produced by cannon firing, I believe that the country would regard with interest some experiments in the matter, and would not begrudge the expense, even if they should prove unsuccessful in leading to a practical use of the principle under discussion. In some other matters connected with science, the government has justly considered that an expenditure of public funds was calculated to be of public benefit; but where, in anything of the kind it has ever undertaken, has there been so promising a field for such action as here? A just and equal regard for the interests of different classes of the people also requires that, if the production of rain at will and at moderate expense is within our reach, it should be known, and known, that it should be acted on. The system of storm telegraphy is for the benefit of commerce; let the interests of agriculture also be considered. I do not forget that it is claimed that the weather telegrams and predictions are for the benefit of agriculture as well as of commerce, but it would be difficult to show in what way they practically are so.

And if it is a legitimate subject for legislative expenditure to provide a means of giving warning to the merchant and shipper of the approach of hurricanes, or for giving notice, each day, to the dwellers in cities of the probabilities of the weather for the day, it is no less so to provide relief for the farmer when his fields are parched with drouth, if this is practicable. And if millions can be appropriated for topographical and irrigation surveys which, in the end, may make the land to be reclaimed cost double its value, and, apparently, can only inure to the benefit of a later generation; ought not a few thousands to be appropriated to test the value of a plan designed to benefit the farmers of to-day, and whom these costly surveys can never help? A remark of Prof. Maury, in writing* on a subject relating to the work of the Signal Service, will apply with equal force to this. He says: "Hundreds of thousands of dollars are lavished upon scientific expeditions for the observations of eclipses, for prosecuting geologic speculations, the survey of distant lands, and even for explorations in Arctic ice in search of the mysterious pole. How insignificant are such objects when placed by the side of that now before us!"

No one, of course, will understand me as proposing that the government should proceed at once to

*In *Scribner's Monthly* for February and March, 1871.

establish stations through the country for the purpose of furnishing rain in different sections as it is needed; what is known of the subject is entirely insufficient, as yet, to warrant such a procedure. When the power of steam was first discovered the world was not ready to build steamships and railroads; nor, when the first electric battery was made, was it ready to lay telegraphic cables under the Atlantic. But from small beginnings that promised much less than does to-day the undeveloped principle presented in this book, how much has the world accomplished! Yet it has only been done through experiments, patient and persistent; experiments that, had they been as costly as those which are now proposed, would never have been made, and man would have remained to this day unconscious of half his powers.

But the proposed experiments, though costly considered as an individual undertaking for any but the very wealthy, would be but a trifle to a great nation like ours. We have the powder, and we have the guns and the men to serve them, and we ought not to leave to other nations nor to after ages the task of solving the great question as to whether the control of the weather is not, to a useful extent, within the reach of man.

It is time, also, that some new methods should be adopted in the study of meteorology. Thousands

of observations are taken and recorded of barometric heights, temperatures, etc., that have no practical value whatever. We live at the bottom of the great ocean of the atmosphere—an ocean that has its tides and its currents—its eddies and its whirlpools—its calms and its storms—its heat and cold and moisture—and the most stupendous movements in that ocean take place far above us, and are invisible to us. The meteorologist, with his barometric and thermometric and hygrometric and other instruments, can note some of their effects—too often treating these effects as causes—but there are great verities in connection with them which his instruments can never reveal to him. I do not decry the value of such observations to a certain extent; but expectancy needs to be supplemented with action, and to the observation of changes and conditions should be added the force that will compel them.

I append some letters from distinguished officers and others in regard to the matter under discussion. My apology to the writers for the use so made of their favors, is found in the importance which I believe the subject to possess and in the impossibility of presenting it in its proper light except by showing how the phenomena which I have described are regarded by some of those who witnessed them. As documents in support of what has been advanced, they are too valuable to remain hidden from the

world; and as they relate wholly to matters connected with history and natural philosophy, I believe there can be no impropriety in making them public.

APPENDIX.

LETTERS AND OTHER PAPERS.

No. 1.

From Brevet Major General Elisha G. Marshall, U. S. A.

ROCHESTER, N. Y., *Dec.* 7, 1870.

MR. EDWARD POWERS:

Sir—Yours of Nov. 28 was received a few days ago. In reply, I would state that your article I have seen in many of our scientific papers, and was then pleased with your views, as often myself and other officers, during the war, were well acquainted with the fact that artillery firing, etc., caused rain.

I will give you facts, which I happen to recollect as far as Grant's campaigns.

First Bull Run—One day's fight. Heavy rain next day.

Second Bull Run—Two days' fighting. Heavy rain day after fighting, extending beyond our retreat at Centreville.

Malvern Hill—Two days' fighting. Very heavy rain next day after battle, extending to our retreat at Harrison's Landing.

First Fredericksburg—Heavy rain after fight.

Antietam—Heavy rain.

There was a rain after Chancellorsville, and, as far as I can recall, after every battle where much artillery was used through all of Grant's campaign.

Grant's campaign was more of one continuous fight from Wilderness to end of war, so that I would not pretend giving data.

The above notes are given you after conferring with Brevet Major General C. J. Powers, Vol., Col. 108 N. Y. Vols., who happened in at this time. Your theory, in reference to this phenomena I consider correct, and deserves full consideration from Congress, and research; and I shall be glad to assist you in obtaining the hearing of those you wish, as far as my humble means go. You will find that every officer, almost, of any education or thought,

will be apt to agree with your views, as this matter was often spoken of during the war.

Is it not the same principle we call to operation when we fire artillery over the spot of a drowned person?

Cannot the Surgeon General, from his surgeons' meteorological observations, give you fuller data,* or put you in correspondence with his corps, who were present at every battle, and they, after careful thought, give you all you seek? You will find the reports of army surgeons reliable.

Truly,

E. G. MARSHALL, *U. S. A.*

No. 2.

From General Joshua L. Chamberlain, Governor of the State of Maine.

STATE OF MAINE, EXECUTIVE DEPARTMENT,
AUGUSTA, *Dec.* 12, 1870.

MY DEAR SIR:—My Adjutant General has sent me your letter, referring to the effect of heavy firing on the atmosphere leading to storms and rain. It is a most interesting matter. The *fact* of such sequences (if they may be called so, without begging the question,) I have often noticed. Certainly a heavy storm of rain occurred after the great battles of Antietam, Fredericksburg, Chancellorsville, Gettysburg, the Wilderness, Spottsylvania, Bethesda Church (or Coal Harbor), Petersburg, Five Forks, etc; and often, I well remember, in what we called small engagements (though they would be called battles in Europe), such as the fight on the "Quaker Road," March 29, 1865, for a late instance, in which there was a sharp, concentrated fire of infantry and artillery for a couple of hours, a very heavy rain would surely follow. This fact was well noticed, and is well remembered by many a poor fellow who, like myself, has been left lying, desperately wounded, after such engagements—for these rains are balm to the fever and anguish of the poor body that is promoted to the ranks of "casualties."

*Col. C. H. Crane, Assistant Surgeon General, says, in reference to this matter: "Very few meteorological reports were sent to this office during the war, and those few came from posts distant from the scene of hostilities."

I am sure you will find my testimony confirmed by the recollections of every soldier.

* * * * *

JOSHUA L. CHAMBERLAIN, *Governor*,
Late Brev. Maj. Gen. commanding 1st Div., 5th Corps.

No. 3.

From General Elliott W. Rice, late of Iowa.

OFFICE OF ELLIOTT W. RICE, ATTORNEY AT LAW,
1424 F ST., WASHINGTON, D. C., *Nov.* 8, 1870.

MR. EDWARD POWERS, Chicago, Ill.:

My Dear Sir—I have your letter of Oct. 22, enclosing your letter in the *Post* in relation to storms produced by firing of cannon. I remember well that many of our heavy battles were followed by rain. At Donelson the weather was clear and cool and exceedingly pleasant, but soon after the engagement a snowstorm was upon us, which was followed by rain. Sunday morning of the battle of Shiloh was clear and beautiful, almost—yes, entirely—beyond description. The day's terrific battle was followed by a drenching rain, that all who were there must well remember. The same thing occurred in the Atlanta campaign, particularly at Dallas; also, at first Bull Run; at Gettysburg. In fact, the occurrence was so frequent that there can be but little doubt that the rain, in many instances, must have been produced by the commotion produced by battle. A Confederate Colonel, now in my office, informs me that it was frequently remarked, in their army, that great battles were frequently, if not generally, followed by storm. I trust you will pursue this interesting subject, which may result in a discovery of incalculable benefit to the world. I regret that I have not time to write to you more fully on the subject.

Very truly, E. W. RICE.

No. 4.

From Gen John McNulta, of Illinois.

BLOOMINGTON, ILL., *Dec.* 13, 1870.

EDW. POWERS:

My Dear Sir—In reply to your favor of the 10th, not only has it been my experience that rain follows soon after every heavy

cannonading, but that this was very generally conceded and understood in the army, and acted upon by the soldiers in preparing for it after every battle. I remember, particularly, that in the garrison at Lexington, Mo., when water could not be had, it was urged by myself and other officers encouraging the men to hold out for a few hours, and that the cannonading would bring rain to quench their thirst; and it did bring the rain, but found us without the means to catch it in sufficient quantities. There are large numbers of soldiers in your city who will remember this circumstance, and the wringing of their blankets to get water.

I have often thought of the matter, and am well satisfied that the theory you advance, in the printed slip sent me, is correct; and, also, that the rain is produced quicker when there is no wind (unless it be a wet wind) than with wind, unless there be a range of hills or mountains to the leeward.

The officers of the Mississippi fleet could, I think, give some important facts, from their shelling small squads of the enemy on shore, with reference to this matter. The inauguration of Gov. Hahn, at New Orleans, was accompanied with cannonading, and noise of musical instruments and anvils, infantry firing, etc., and was soon followed by very heavy rain. When the rebel ram ran by the city, the cannonading, only for a few minutes, was followed by rain. The passage of the forts at Mobile bay, the bombardment of Fort Gaines, afterwards of Fort Morgan; again of Spanish Fort and Blakely; the landing of our troops at Pascagoula, and firing a few shots with field pieces on shore; the battle of Sterling Farm, and the fight on the Atchafalaya river were followed, in a few hours, with heavy rains.

I was with the first troops that passed down the river (Herron's Division, 13th Army Corps,) after the surrender of Vicksburg, to Port Hudson. We found it very muddy there (July) and also at Yazoo City, when taken by our troops, July 12, 1863. Everybody remembers that there was no trouble in keeping *moist* at Vicksburg. It rained, after cannonading, at all the places named; but why I have named this region of country is because it seemed to impress me with its peculiar susceptibility in this respect. I believe that in the dryest time, without wind, or a light wind off Ponchartrain, the firing of one hundred guns at New Orleans will bring on rain in a few hours, and almost certainly in large quantity.

At the inauguration of which I speak, I obtained, during the firing, a seat on a housetop, on Lafayette square, where I could look down and see the multitude. It was, literally, as *dry as a chip*, without a cloud to be seen, when the ceremonies commenced. (Chimneys presented the appearance of miniature volcanoes, spasmodically sending up soot, and here and there one with fire and ashes. The escape of the compressed air from a chimney, occasioned by the concussion of artillery, is infinitely greater than would be supposed. There seems to be a sort of hydraulic pressure to it.) My recollection now is that the artillery practice had not commenced more than an hour when there was a perceptible change in the atmosphere—a kind of haziness. That night and the next morning it rained "*fearfully* hard."

What effect would be produced on our prairies I am unable to say, yet believe the difference could not be great, as the aqueous vapors contained in our atmosphere cannot be much less than in that near the ocean or large rivers. At the battle of Prairie Grove, Ark., the wine blew parallel with the mountain range. I suppose there was an average of twenty field guns in constant use for five hours. Cloudy at dark or a little after (Dec. 7). At 2 o'clock a. m., 8th, the atmosphere was remarkably clear, and the stars shone with unusual brilliancy. At 3:30 it was "pitch dark." Daylight showed a few filmy clouds, with the light wind blowing against the mountain range. M. brought rain.

Soon (several days) after we crossed the Boston Mountains we found a light breeze blowing against the mountains from the opposite side. We had some artillery firing—say thirty or forty rounds—near Lee's creek, early in the morning, with a clear sky. Here I remember that it was urged by some of our officers that artillery should not be used on the small number of the enemy's cavalry that were in front of us, for the reason that *it would bring on rain*, and thereby retard us in the pursuit of the enemy. We got the rain in less than two hours. After the firing at the capture of Van Buren, the wind still light, moving nearly at right angles with the mountain range, we got rain in a few hours.

I remember that the rain following the several engagements on Mobile bay was more copious than I ever witnessed before—the cannonading by the army and navy being unusually heavy, especially at the lower forts. This, you will remember, was in the summer, or dry season. It is possible that I may have known an

instance where there was heavy firing that was not followed by rain, and that the matter may have escaped my notice. There are other instances when I know it did occur, but deem it unnecessary to cite them, as I have given you the cases that seem most important, and which attracted my attention. I am compelled to hastily refer to the matter, and have scarcely time to read what I have written, and would not have written this much but from a desire to encourage you in prosecuting your investigations, for I seem to know you are right. I hope you may succeed in fully demonstrating your theory, and in making some practical use of it.

There are, as you doubtless are aware, animals that anticipate a storm—hogs, for instance. If you have an opportunity, after the firing of a salute of say thirteen or fifteen guns, observe them carefully, and I think you will find them acting as they do preceding a storm, although there may be no rain.

Truly yours,

J. McNULTA.

No. 5.

From Gen. R. H. Milroy, of Indiana.

DELPHI, IND., *Dec.* 19, 1870.

MR. EDWARD POWERS:

Dear Sir—Yours of the 8th inst. was duly received, containing the enclosed printed slip, and asking me to state whether, in my military experience, I had noticed the fact "that battles are generally followed by a rainfall." I regret that my attention was not called to this matter during the war that I might have noticed and made note of such facts, as I doubt not their existence. The Espy theory of producing rain is the only one I recollect hearing of prior to our late war. About the close of the war I heard it mentioned that heavy artillery firing produced rain, and in looking back over battles in which I participated, or was near, I thought I could see strong proof of the theory. The battle of Rich Mountain, in July, 1861, was followed by some one or two rainy days; Cross Keys, in June, 1862, the same; second Bull Run, August, 1862, two days' heavy firing in dry weather, followed by refreshing showers; Gettysburg battle, heavy artillery firing for two days, in July, 1863, followed by such heavy rains as to raise the Potomac, and stop the

retreat of the rebel army for some days; battle of Franklin, Tenn., about the 1st of December, 1864—fine weather at the time of and previous thereto for many weeks, but was followed by rain that froze as it fell, and covered the country with ice; battle of the Cedars, near Murfreesboro, Tenn., in December, 1864, preceded for some days by artillery firing from Fortress Rosecrans, was followed by rains; the battle of Nashville, soon afterwards, was followed by much rain.

These are all the instances I can now recall of "Heavens weeping o'er our battles." There is more artillery being used in the battles now going on in France than was ever used in any preceding war on earth, and the newspapers tell us that France has been having extraordinary quantities of rain and great floods. May not this fact account for our pleasant dry fall and winter, so far?

There are none of the laws of nature of which science is so utterly ignorant as those governing weather, and yet there are no laws the knowledge of which would be of more benefit to mankind. You are, therefore, engaged in a most noble and beneficent inquiry, and I most sincerely wish you success, and hope that Congress will grant you all you ask to enable you to prosecute your experiments. There is no reason why science should not obtain a knowledge of and utilize the laws governing weather.

Begging pardon for my delay in answering your inquiry—occasioned by my press of business—and for the hasty and unstudied manner of the foregoing answer,

I am, very respectfully and truly,
Your most ob't serv't,
R. H. MILROY.

No. 6.

From Prof. Benj. Silliman, of Yale College.

NEW HAVEN, *Nov.* 19, 1870.

ED. POWERS, ESQ.:

Dear Sir—In reply to yours of the 11th, received to-day, I have to say that it by no means follows that in times of drouth the atmosphere does not contain a considerable quantity of water, dissolved as vapor. The capacity of the air for moisture increases with the temperature, and, in our country east of the Rocky Mountains, we seldom see a state of the air where it does not

contain a large amount of moisture. The amount of moisture requisite for saturation of air at different temperatures, is as follows, viz.:

1	cubic	meter	of	air,	at	0° C,	holds	5.4 grammes.
1	"	"	"	"	10°	"	"	9.74 "
1	"	"	"	"	25°	"	"	22.5 "

In very dry climates the air is often very low in moisture, as at the Red Sea, during a simoon, when not over $\frac{1}{15}$ of saturation is present. In this latitude, 60 per cent. of the saturation is a usual and healthful quantity. The "dew point," of course, is the test of saturation. I have seen, in Arizona, 40° F. difference between the wet bulb and the dry bulb thermometer, and there, I believe, no cannonading would bring rain out of the air.

I consider, however, that the matter you have in hand is a perfectly fair subject of experiment, and in view of the fact that there are times (and we have all seen such) when a good shower would be worth millions of dollars in money, it is certainly worth a few thousands spent in noise, at a proper time, to determine the question, "Will He bow His heavens and come down?"

Yours respectfully,

B. SILLIMAN.

No. 7.

From Brevet Major General Henry W. Benham, U. S. Engineers.

BOSTON, MASS., *Nov.* 15, 1870.

MR. EDWARD POWERS, Chicago, Ill.:

Dear Sir—I have been greatly hurried, during the past few weeks, so that I have not had time to reply, as I would desire to, on the subject of your inquiry as to my opinions or experiences in the matter of the effect of cannon firing to cause rain at any or all states of the atmosphere.

I would say to you now, however, very briefly, that I have a most decided conviction on this subject—as I have had for many years,—and that is, that the firing of cannon, to any great extent, will always, or almost always, cause rain. Independent of several cases in the last war of the rebellion, where rain accompanied or followed the battles in quick succession, I will only now refer particularly to one case, which, I doubt not, the recollections of

many men in your vicinity who were members of Hardin's or Bissell's regiments, at the battle of Buena Vista, February 23, 1847, will corroborate. This is the fact: that about one or two hours after the severe cannonading between 8 and 10 A. M.—that is, between 11 and 12 o'clock—we had a most violent rain-fall for some ten or fifteen minutes. I recollect holding my body forward over my holsters, and bringing up my frock coat skirts to keep my holsters and pistols dry. Again, in the afternoon, at about the same interval, after the last fatal charge, when Colonels Yell, Hardin, McKee, and Lieut. Col. Clay fell,—when there was a heavy cannonading a second time,—another violent shower of rain fell, wetting us all again. And what I considered the *satisfactory proof* that this was caused by the shocks to the atmosphere produced by the cannon fire, is the fact that no rain had fallen in that vicinity for many months previously—I was told six or eight months,—and none fell, *as I know* was the case, for three or four months after that battle, as I continued at that position.

Trusting this may be of some use as an item towards substantiating your views, which, I do not doubt, can be utilized, as you proposed,

I am, very truly yours,

H. W. BENHAM.

No. 8.

From General Geo. W. Smith, of Illinois.

LAW OFFICE OF GEO. W. SMITH,
No. 86 WASHINGTON ST., CHICAGO, *Feb.* 21, 1871.

MR. EDWARD POWERS:

Dear Sir—I have your letter of yesterday. In reply, I was present at Perryville, Stone River, Chickamauga, Mission Ridge, the various engagements between Chattanooga and Atlanta, Franklin and Nashville.

I remember that rain followed most of the above named battles, and particularly Perryville, Stone River and Nashville. Chickamauga was succeeded by a dense fog.

Yours, truly,

GEO. W. SMITH.

No. 9.

From General Wm. Vandever, of Iowa.

DUBUQUE, *Oct.* 15, 1870.

ED. POWERS, Chicago, Ill.:

Dear Sir—Your favor of the 13th inst., with enclosed newspaper article, received and read with interest.

I do not think that I can give any particular information to guide you in your investigations. My observation, however, during the war, satisfies me that your theory is correct. Great battles were generally followed by storms of rain. This peculiarity was often the subject of comment in the army.

If, from such facts, you can suggest any feasible mode of bombarding the clouds and bringing down rain, the country will be indebted to you.

Very truly yours,

WM. VANDEVER.

No. 10.

Extract from a Letter from the Adjutant General of the State of Ohio, dated Columbus, Oct. 17, 1870.

* * * * Your theory has always been a pet "hobby" of my own and my observation, during the late war, led me to believe in its correctness. I have always noticed that heavy firing was followed by copious showers, with an uniformity which satisfied me that it was not mere coincidence. The best way to decide the matter, however, would be to institute a series of experiments during dry weather, when the barometrical signs indicated a continuance of drought.

Very respectfully, your obedient servant,

WM. A. KNAPP, *Adjutant General.*

No. 11.

Extract from a Letter from the Adjutant General of Wisconsin, dated at Madison, Oct. 26, 1870.

* * * I had occasion to notice myself that our battles were generally followed by rain during the war.

At Cedar Mountain, August 9, 1862, the battle was followed by a slight rain. The weather was, at the time, intensely hot, and the engagement was short, and but little artillery used. At the second battle of Bull Run, August 27 and 28, 1862, the rain poured in torrents. The closing engagement of that series of battles, that of Chantilly, was stopped by a drenching shower. At Chancellorsville, May 3, 1863, we had torrents of rain in about forty-eight hours after the cannonading was over. At Beverly Ford, June 9, 1863, we brought on rain by a sharp musketry and artillery fire, lasting half a day. At Gettysburg, where some three hundred cannon pounded from 12 till 4 o'clock, and musketry incessantly for three days, we had a night and day of pouring rain, setting in about six hours after the firing had ceased. Yours respectfully,

E. E. BRYANT, *Adj't General.*

No. 12.

The foregoing letter fixes, approximately, the time of the commencement of the rain at the battle-field, after the battle of Gettysburg. The following extract from a letter from Colonel John Gibbon, 7th Infantry, U. S. A., speaks of the same rain as it occurred at a point some thirty miles southeastward.

"Immediately after the battle of Chancellorsville, there was a terrific rain storm, May 5, 1863. This was also the case after the battle of Gettysburg, the rain commencing to fall about twenty-four hours after the heavy cannonading of the 3d of July; and at Westminster, about thirty miles from the battle-field, continued to rain heavily all night."

No. 13.

Mr. Abbott Mott, of the Engineer Department, U. S. A., in a communication to an officer, says of the commencement of the rain at Fredericksburg:

"At the battle of Fredericksburg, I was on the skirmish line the night of the retreat, and consequently, was among the last to cross the Rappahannock on said retreat. I distinctly remember a very heavy rainstorm commenced while we were crossing on the pontoon bridge. This battle was notable for the amount and weight of ordnance used."

No. 14.

From General J. A. Garfield, of Ohio.

HIRAM, O., *Oct.* 28, 1870.

EDW. POWERS, Chicago, Ill.:

Dear Sir—In answer to yours of the 22d, I have to say that, while I did not take such observations as a scientific experiment requires, I did observe the frequent occurrence of heavy showers very soon after the battles in our late war. It was a matter much talked of in the army, and there was a general impression that the atmospheric disturbance caused by heavy cannonading, hastened or created showers. I remember that heavy showers followed almost immediately after the battles of Shiloh, Stone River, Shelbyville and Chickamauga. But while these coincidences are curious and interesting, they are chiefly valuable from the fact that they challenge the attention of scientific men, and may lead to a discovery of causes which will prove valuable to our knowledge of meteorology. Very truly yours,

J. A. GARFIELD.

No. 15.

From Gen. J. M. Hedricks, of Iowa.

COURIER OFFICE, OTTUMWA, *Oct.* 28, 1870.

MR. EDWARD POWERS, Chicago, Ill.:

My opinion fully concurs with the theory of your article. I have, however, never taken time to investigate the phenomena sufficiently to give you an intelligent theory on the subject at present.

It is a highly interesting and important matter, and should be investigated.

In great haste, your ob't servant,

J. M. HEDRICKS.

No. 16.

From Gen. Jas. Barnett, of Ohio, late Chief of Artillery, Dept. of the Cumberland.

CLEVELAND, O., *Oct.* 28, 1870.

EDWARD POWERS, ESQ.:

Dear Sir—I am in receipt of your favor of 22d inst., enclosing your article from the *Evening Post*. It was a remarkable fact, which I think most of our army officers will recollect, that many of our battles were accompanied with rain, or rain immediately followed. Such was the fact at Pittsburg Landing and Stone River, and I think at other general engagements in our department. Chickamauga and Mission Ridge may have been exceptions, but of this I am not sure. Our advance from Murfresboro, in which a good deal of artillery firing was done, was accompanied by rain all the way. I desire to talk with some of my army friends, who assemble here on the 24th ult., and will take pleasure in writing you further on the subject after we compare notes.

Yours,

J. BARNETT.

No. 17.

From Gen. Rutherford B. Hayes, of Ohio.

STATE OF OHIO, EXECUTIVE DEPARTMENT,
COLUMBUS, *Oct.* 31, 1870.

Dear Sir—Your favor, with slip enclosed as to rain following battles, is at hand. There was a notion of the sort often mentioned in the army I belonged to. Off hand I have no opinion about it. Rain followed within twenty-four hours in the following cases:

Carnifax Ferry, Sept. 10, 1861.
Dublin Bridge, May 10, 1864.
Winchester, July 24, 1864.

No rain after:

South Mountain, Sept. 14, 1862.
Lynchburg, June 20, 1864.
Winchester, Sept. 19, 1864.
Fisher's Hill, Sept. 22, 1864.

Other battles I don't recollect about.

On hearing of the attempt to investigate this subject by you the most conspicuous fact occurring to me was against the theory suggested.

In August and September, 1864, the Shenandoah Valley was the scene of unending warfare—daily battles—cannon firing from daylight to dark, and with it an unusual drouth. In September, 1870, no cannon firing, and an unprecedented flood.

But my memory supplies too few facts to warrant an opinion.

Sincerely

R. B. HAYES.

While I accept the affirmative evidence given in the foregoing letter, I trust that my distinguished correspondent will pardon me if I show that his memory was at fault in relation to some of the matters of which he speaks, and that the argument he draws against my theory has really no "conspicuous fact" for its foundation. It will be seen from the paper which follows that an actual record has been kept of ten different rains occurring in the region of which he speaks between Aug. 18 and Sept. 16, 1864, inclusive. The man who kept this record was killed at the battle of Opequan Creek, which was the second battle of Winchester, spoken of in the foregoing letter, and his record is therefore silent in regard to the weather following that battle. As mentioned on page 66, however, it rained in the southeastern part of the same State on the second day after this battle; also on the day after the battle of Fisher's Hill, as shown by the weather record of the steamer Agawam, then on James River.

No. 18.

*Extracts from the Diary of Lt. W. Ashley, of Vaughn's Brigade, Co. C Battalion, Thomas' Legion, Wharton's Division, Breckenridge's Corps, Gen. Early's Army; who was killed at the Battle of Opequan Creek, near Winchester, Va., September 19, 1864.**

Newmarket, Va., Saturday July 1, 1864. Daylight. Start through Edinburgh, * * * hot * * * .

July 2. Strasburg. Straggled and got a good dinner; encamped near Middletown.

July 3. Start through Newtown * * * .

July 4. Start to Martinsburg. Yanks had left in a hurry. Lots of plunder, * * * still hot and dusty.

July 5. Clear. * * * Marched to Potomac River, near Shepherdstown; waded it. * * *

July 6. Clear; still no rain. * * * Made foot of Maryland Heights about 11 P. M.

July 7. Cannonading all night; daylight start; we are now in position as reserve. Sharp fighting going on immediately in front; shells coming unpleasantly near every once in a while; passed over a man's foot in our road just now taken off by a cannon ball; suppose we are about one mile from their works. Harper's Ferry; dark; moved out over mountain to Rollersville by 2 A. M.; rain, rough and very dark.

July 8. Clear. * * * Awful rain during the night, all and everything wet through. * * *

(The diary shows no more rain until after the battle of Winchester, fought July 24, 1864.)

July 24. Clear; army in motion * * * * heavy shells and bullets coming thick among us * * * * drove the Yanks under a hot fire several miles through Winchester. * * *

July 25. Rain; all wet through and cold. * * *

August 17. Clear at daylight; ordered into front * * * ordered to charge the enemy; did so, under a heavy fire of artillery and small arms. * * * The fight was continued until 11 P. M. * * *

August 18. Rain. * * *

August 19. Hazy. * * * Skirmishing near Berryville.

*See Putnam's "Record of the Rebellion," Vol. XI. p. 153.

August 20. Rain. * * *

September 3. Cloudy. * * * Heavy artillery and musketry in direction of Berryville; rain; still fighting far away into the night.

September 4. Cloudy. Started to scene of last night's action * * * sharpshooters already engaged. 3 P. M. Flanked to left, and lay until night, endeavoring to draw them out to fight. They won't leave their entrenchments; bullets are whistling around us close. * * * Rain, cold and disagreeable.

September 5. Rain. Skirmishing heavy * * * heard firing in our front. * * * Rain falling heavy. * * *

September 6. Rain all day. * * *

September 9. Clear, cold night * * Smart skirmishing. *

September 10. Rain. * * *

September 12. Rain. * * *

September 13. Clear; fighting on our left; * * * fighting is winding to our right; * * * it is very heavy. 2 P. M. Cannonading heavy on our right.

September 14. Rain. * * *

September 15. Cloudy. * *

September 16. Rain. * * *

No. 19.

From Major General S. P. Heintzelman, U. S. A.

NEW YORK, *Nov.* 6, 1870.

EDWARD POWERS, ESQ., Civil Engineer, Chicago:

My Dear Sir—Your letter of the 6th of October, with its enclosure, I have received, and gladly contribute my mite towards the establishment of your theory.

I have been keeping a journal all my life, mostly a mere record of facts, and as a general thing I mention the weather. The enclosed notes have been carefully extracted from this journal. I find that I have recorded, almost daily, the weather, and whether there was firing, from the first Bull Run, July 21, 1861, to September, 1862, when I was placed in command of the defences of the south side of the Potomac.

I have the impression that rain can be produced by the concussion of the atmosphere; and the only question in my mind has been,

will it pay? It will depend upon the area of country that can be affected. Can not some cheaper material be employed to produce the concussion than gunpowder?

A curious fact was brought to my mind the day after I received your letter. In conversation with a gentleman who moved on the Southern side, he inquired whether I had ever observed that during the war in Virginia there were no turkey buzzards in the vicinity of the armies. I recollect the fact, and attribute it to the great extent of atmosphere affected by the concussion of artillery firing, thus driving those timid birds away. This would go to show that the atmosphere is affected to a sufficient extent to make it practical, or that it will pay.

These observations have a greater value, as when they were recorded I had no theory to sustain.

I am, sir, yours truly,

S. P. HEINTZELMAN.

No. 20.

Notes from Journal kept by S. P. Heintzelman, Commanding Third Army Corps, from July, 1861, to September, 1862.

July 21, 1861. This was a clear, hot day—the first battle of Bull Run. I reached my door in Washington the next morning, at 6½ a. m. "It commenced to rain a little before we got in."

Camp Winfield Scott, Yorktown, Va., Saturday, May 3, 1862. "Threatened rain this morning, but turned clear and pleasant. * * * Some five hundred shots and shell were fired yesterday by the rebels. Not much firing to-day." * * "The rebels were very busy till after midnight firing" (artillery).

Sunday, May 4, 1862. * * "This is a beautiful morning." Rain commenced Sunday night. "It commenced raining in the night."

The battle of Williamsburg was fought Monday, May 5, 1862. It rained all day and into the night. My impression is that it was clear the day after the battle.

Williamsburg, May 8 (Thursday), 1862. "A beautiful day." Wednesday was Franklin's affair at West Point.

Savage's Station, Saturday, May 31, 1862. "We had a very heavy thunder storm late in the afternoon yesterday, and till in the night. It rained in torrents. * * It has been cloudy all day."

Savage's Station, June 1, 1862. "The clouds broke away early in the day, and it was warm."

Savage's Station, June 2, 1862. "Before daylight I got another dispatch from Marcy to sustain Sumner with all my force. As I had already made arrangements for any contingency, I did not get up till it got light. It was then raining* a little. I dressed, and when the sun rose we had a rainbow. I think we will have a pleasant day."

Savage's Station, Tuesday, June 3, 1862. "Heavy rain and thunder storm last night. This morning has been hot. Mercury, at one time, in my tent, 94°." * * "All the wounded of my troops, and the prisoners, were sent off in the last train at 9 P. M. It commenced to rain pretty steadily before."

Savage's Station, Wednesday, June 4, 1862. "It rained more heavily last night and this morning, till about 9 A. M., than I have known for years. The whole country is flooded, both in the front and on the left. No enemy can move, even should he try, which I don't think he intends on this flank, after his defeat."

Savage's Station, Thursday, June 5, 1862. "It has been cloudy, and threatening rain with a few drops to-day."

Savage's Station, Friday, June 6, 1862. "It has been cloudy, and drizzled several times during the day. The weather is disagreeable enough."

Savage's Station, Saturday, June 7, 1862. "Cloudy this morning, but sun came out. In afternoon, a thunder storm, and now clearing off."

Savage's Station, Sunday, June 8, 1862. "This has been a pleasant day."

Savage's Station, Monday, June 9, 1862. "Quite cool, but pleasant, drying winds."

Savage's Station, June 10, 1862. "Rain† most of the night and this morning. Now a mist." * * "From top of a tree got a sketch. Two rebel flags were seen on a large building in Richmond, from this tree."

Savage's Station, Wednesday, June 11, 1862. "Cold last night.

*The rains of June 2, 3 and 4 followed the battle of Fair Oak or Seven Pines, fought May 31 and June 1, 1862. The heaviest of these rains, it will be noticed, fell on the night of June 3, and morning of June 4.

†Fremont's battles of Cross Keys and Port Republic, in Virginia, were fought June 8 and 9, 1862.

Rain ceased in the night, and pleasant to-day. High winds drying the roads rapidly."

Savage's Station, Saturday, June 14, 1862. "A beautiful morning."

Savage's Station, Sunday, June 15. * * "We have some thunder and lightning, with rain, and the air cooled greatly. From 93° to 66°. The enemy have been firing at our pickets, and we have lost some men, both in front of Hooker and Kearney."

Savage's Station, Monday, June 16, 1862. "Cool, but pleasant morning. Mercury, 57°. A great change since yesterday. We have had considerable skirmishing yesterday and to-day."

Savage's Station, Tuesday, June 17, 1862. "Cool night and all day. Mercury very little above 70°, and cool wind. * * The gunboats were firing near two hours to-day."

Savage's Station, Wednesday, June 18, 1862. "Cool last night and this morning, but getting warm again. * * About sundown there was some picket firing in front of Sumner, with rapid artillery firing. It lasted only a few minutes. * * Since dark, a heavy wind and rain."

Savage's Station, Thursday, June 19, 1862. "The rain, last evening, did not last long. This morning the roads are dusty. * * Cool morning, but warm day."

Savage's Station, June 21, 1862. "Warm and dusty to-day. It was unusually quiet all day, till late in the afternoon, when, suddenly, a brisk fire of musketry rang along Hooker's front, followed by artillery."

Savage's Station, June 22, 1862. * * "There was picket firing, at intervals, most of the night. At ten minutes before 3 A. M., several volleys were fired in rapid succession, * * but it only lasted a few minutes. * * We have had a few drops of rain since dark. * * Mercury has been 93° to-day, and little wind."

Savage's Station, Monday, June 23, 1862. "Quite warm till afternoon, and then showers of rain with a little thunder. * * All has been very quiet since yesterday morning. What can all this mean? * * It is quite cool since the rain, with some rain and lightning, and may rain more."

Savage's Station, Tuesday, June 24, 1862. * * "We had a very heavy rain storm, and thunder and wind, at midnight. The telegraph wires are down. * * At dawn, heavy musketry com-

menced, and soon followed by artillery. I thought it the attack, and had all up, but it did not last but a few minutes. We afterward heard the rebels beat reveille. Had another heavy rain a little before night; has cooled the air much."

Savage's Station, Wednesday, June 25, 1862. "The rain made the morning and day pleasant."

[NOTE.—This is the affair of the "Orchards," in which my command lost some five hundred men, and pushed forward our pickets —the object of our attack.]

Savage's Station, Thursday, June 26, 1862. "For several hours this afternoon, heavy artillery firing has been going on, on our right. * * The firing is very steady and continuous, although it is getting dark. There must be quite a battle." [NOTE.—This was the battle of Mechanicsville.]

Savage's Station, Friday, June 27, 1862, 5½ P. M. "The battle still continues on the right." [NOTE.—This was the battle of Gaines' Mills.]

Savage's Station, Saturday, June 28, 1862. "At 3 A. M., a heavy picket firing commenced, then joined in with artillery. * * There was, occasionally, artillery and some musketry firing during the forenoon. The enemy made a very determined attack on General Smith, and got into one of his redoubts. His infantry drove them out, etc., etc. * * I feared, this morning, it would rain." "In the night of the 28th, got an order to fall back to the lines I held May 31. * * * It was foggy." [NOTE.—On the 29th the battle of Savage's Station was fought.]

Junction Charles City and Quaker Roads, Monday, June 30, 1862. [NOTE.—Battle of Glendale fought.]

Thursday, July 2, 1862. * * "It commenced raining soon after light." [NOTE.—This was at Malvern Hill—the day after the battle.] * * "It was now about 6 A. M., and raining hard."

Berkley's Farm, Thursday, July 2, 1862. "It rained hard in the night, and it is doubtful whether it will clear off now. * * At half-past 10 A. M., the rebels commenced throwing shells into our camp, etc. * * It has not rained since morning, but it is not clear yet."

Near Berkley's Farm, Friday, July 4, 1862. "Clear sunshine. The roads and ground are drying rapidly."

* * * * * * *

Harrison's Bar, Tuesday, July 15, 1862. * * "Mercury was 96° to-day, but at dark a heavy thunder storm, and now down to 74°. * * There has been some gunboat firing down the river."

Harrison's Bar, Wednesday, July 16, 1862. "Mercury, 90°. In the evening, a heavy thunder shower."

* * * * * * *

Junction of Warrenton and Alexander and Orange Railroads, Tuesday, August 26, 1862. "The weather, the last few days, has not been very hot, but quite dusty."

Warrenton Junction, Wednesday, August 27, 1862. "There was some artillery firing in the night, and again this morning."

Manassas Junction, Thursday, August 28, 1862. "Some artillery firing on our left, at 8 A. M." [NOTE.—On the 27th was the affair at Bristow Station.] * * "We had quite a heavy shower as we passed Manassas Junction, but it only extended a short distance." [NOTE.—On the 27th, in the evening, about 9 P. M., we had a little rain. The ride from Warrenton Junction to Bristow Station, on the 27th, was very warm and dusty.]

Bull Run battlefield, near the Henry House, Friday, August 29, 1862. "At 10 o'clock A. M., reached the field a mile beyond the stone bridge. Firing had commenced again." [NOTE.—This is the first day of the second Bull Run.]

Saturday, August 30, 1862. [NOTE.—This is the second day of second Bull Run.]

Centreville, Va., Sunday, August 31, 1862. "At daylight it commenced raining. * * The rain did not last very long, but it is still cloudy. * * There was some firing this morning, but not much."

Fairfax C. H., Va., Tuesday, September 2, 1862. On the day before, between Centreville and Fairfax C. H., "Heavy thunder and rain storm, at 6 P. M. * * After the rain, rode on a mile or so, and stopped opposite Kearney's left flank." [NOTE.—This was near Chantilly.]

Arlington, Md., September 10, 1862. "There has been a heavy wind storm, but scarcely rain enough to lay the dust. Next day, rain showers all the forenoon."

S. P. HEINTZELMAN.

NOTE BY THE AUTHOR.—The memoranda furnished concerning the time the army lay at Harrison's Bar are for the most part omitted, not being of special significance.

No. 21.

From Gen. John C. Starkweather, of Wisconsin.

SUNNY SIDE FARM, OCONOMOWOC, *Nov.* 8, 1870.

EDWARD POWERS, ESQ.:

Dear Sir—My house and its contents having just been destroyed by fire, prevents me (as to time) answering your favor in detail. I can therefore only say, in general terms, that I agree with you fully. Yours truly,

JOHN C. STARKWEATHER.

No. 22.

From Gen. Rob't A. McCoy, of Pennsylvania.

SURVEYOR GENERAL'S OFFICE, HARRISBURG, *Nov.* 14, 1870.

EDWARD POWERS, ESQ., Civil Engineer, Chicago, Ill.:

Dear Sir—Your favor relating to the subject of artillery fire producing rain, and requesting statement of my recollection as to rains following the principal battles of the late war has been received. My time being very fully occupied by official duties, leaves me but little opportunity to make you a satisfactory reply, and the fact that I have not my memoranda book within consulting distance, compels me to write from memory.

The whole scope of my service in the army was in Eastern Virginia, Maryland and Pennsylvania, with the army of the Potomac, and at no time exceeding 200 miles from the Chesapeake or Delaware bays.

This fact should be taken into consideration when considering the effects of our battles on the atmosphere or currents of air. My recollection is, that after the battle of Antietam—one in which much artillery was used—it rained the following day, the 18th September, 1862; that rain fell in considerable quantity on Tuesday after the Saturday of battle of Fredericksburg, Va., in December, 1862—think some rain fell before Tuesday. A very large number of cannon were in position on the Stafford heights and the Fredericksburg and Mayre's heights; the valley between was densely filled with smoke from the discharge of cannon, small arms and the burning of the town. The sight was grand. The sun appeared to toil through the density of smoke.

It rained on the third day, I think, of the Chancellorsville battle, May 3, 1863.

Very heavy rain fell after the battle of Gettysburg; in fact the night of the last day of the battle your correspondent was soaked with rain whilst examining and arranging outposts.

My recollection does not serve me as to the three days of the Wilderness battle, but in the execution of my duties I got very wet one day near the close of the battle of Spottsylvania C. H., 1864.

I omitted to mention that it rained very hard immediately after the second battle of Bull Run, August 31, 1862.

I am not prepared to go into any scientific argument for or against the theory, but believe that the concussions—jarring of the atmosphere by the sound, as well as disturbance of it by the smoke of battle, produced rain.

I am inclined to the opinion, that the smoke is not without its effect in producing rain, for I remember to have observed when a boy, living in the interior of this State, that in the early fall, the farmers who had cleared new lands usually burned the brush and log heaps about one time, causing dense smoke through the valley, and remember that rain usually followed; also after the burning over of mountain lands.

But as I have before remarked, that all my experience and observation have been confined to a narrow limit not far from the sea, where greater moisture exists in the atmosphere than farther inland, perhaps that fact might have had much to do with the frequent rains apparently caused by firing and by smoke. If concussion, or jarring the air, is the moving power, then the firing should be directly up in the air, or rather by batteries placed at say one or two miles apart, and fired into the air at a proper angle and towards each other.

Begging your pardon for inflicting upon you so crude a letter, I have the honor to be, Very truly yours,

ROB'T A. MCCOY,

Late Ass't Adj't Gen'l 3d Div. 5th Army Corps, Army of Potomac.

No. 23.

From General J. M. Campbell, of Pennsylvania.

JOHNSTOWN, PA., *Nov.* 16, 1870.

ED. POWERS, ESQ.:

Dear Sir—Your favor of the 7th inst., with enclosed slip, I find awaiting me on my return home.

At present I can remember but two battles during our late war which were closely followed by rain. The first, after the battle of New Market, Va., on the 15th of May, 1864; the other after the battle of Winchester (Crooks), Va., July 24, 1864. There were, doubtless, others, but I cannot recall them with distinctness. I have heard the idea you advanced frequently discussed since the war, and believe there is "something in it."

Very respectfully yours,

J. M. CAMPBELL.

No. 24.

From General E. L. Dana, of Pennsylvania.

WILKESBARRE, *Nov.* 21, 1870.

EDWARD POWERS, ESQ., C. E.:

My Dear Sir—Since the receipt of your favor of the 7th inst. I have been engaged in holding court, with no leisure until this evening for a reply.

I showed your article to several military gentlemen of this town, who concur in their recollection that nearly every great battle of the late war was either attended, before its close, or immediately followed by a heavy fall of rain; generally with much electric action. The occurrence was the subject of remark. I think on the third day after the commencement of the Chancellorsville movement, and in the midst of a rapid cannonade, there came on a fearful thunderstorm, and, for a time, we were at a loss, in the thick woods, to distinguish the "artillery of heaven" from that of earth.

At Gettysburg, on the 4th of July, the day following the decisive conflict of the 3d, characterized by the heaviest cannonade of the war, there was a severe storm, a large quantity of water falling. There was a slight fall of rain during the battle of the 1st of July, at Gettysburg, and in the evening.

In one of the operations before Petersburg, I think in October, 1864, which was there called the Squirrel Level Road, a heavy rain followed immediately after the action. The same coincidence occurred in the two actions at Hatcher's Run.

The rain which fell at Chancellorsville August, 1863, to which I have referred, you may recollect, was such as to raise the river and threaten our pontoon bridges, and, probably, hastened our re-crossing the river.

These meagre reminiscences touching the question suggested in your letter, with those of General Osborne, to whom I showed your article, are all that I am able to recall distinctly at present. We had many rainstorms, of course, at other times.

The mountains around our valley of Wyoming occasionally take fire, and, after a day or two of burning, form nearly a circle. A rain opportunely occurs, about this time, and extinguishes it. Prof. Espy, some years ago, had a theory of the effect of fires in producing rain.

I am, very truly, etc.,

E. L. DANA.

With the foregoing letter, General Dana was kind enough to forward the following from General E. S. Osborne:

No. 25.

WILKESBARRE, *Nov.* 19, 1870.

GEN. E. L. DANA:

General—The letter of Mr. Powers to you, and also the article containing remarks relative to the supposed effect of artillery fire in producing rain have been read by me, and in compliance with your desire, I would state that heavy storms followed the following battles, viz.: Chancellorsville, Wilderness, North Anna River, Weldon Railroad, and Hatcher's Run. Upon these occasions I am positive that we had very heavy rain, accompanied with thunder. Whether other battles in which the Army of the Potomac was engaged were followed by storms I do not now distinctly remember.

Very respectfully, your obedient servant and friend,

E. S. OSBORNE.

No. 26.

From Brevet Major General Henry J. Hunt, U. S. A.

FORT ADAMS, NEWPORT, R. I., *Nov.* 13, 1870.

Mr. EDWARD POWERS, Chicago, Ill.:

Dear Sir—Your note of the 18th of October, with its enclosure, reached me in due course. My absence for a portion of the time

since, and other duties, have prevented my returning an earlier answer.

I cannot at this time give very accurate answers to your questions respecting the occurrence of storms after battles, but, in many cases, I can remember with sufficient certainty their occurrence, and very nearly the period within which they occurred.

The battle of Churubusco, in the valley of Mexico, was fought on the 20th of August, 1847. The rainy season must have been closed, or near its close. At Puebla, during the months of June, July and perhaps the beginning of August, there were heavy falls of rain *every afternoon*, the skies clearing before sunset, and the atmosphere being remarkably clear until the *next* afternoon; but I remember that on the march from Puebla, which commenced 7th August, the days were, generally, if not always, clear, bright and beautiful. On the 14th the whole day was bright and clear. I was specially engaged that day on duty, which I remember. I believe the 15th was a similarly clear day, as was the 16th, the date of the commencement of the movement round Chalco. There was some little rain on the 17th or 18th, but it was not, I believe, very heavy. The 19th was clear and beautiful in the afternoon, at the usual hour for rains. I remember that I was watching the movement taking place at Contreras from a distance at the time. I think that night was cloudy, dark, and perhaps rainy. I do not think the rain was very heavy. There had been cannonading at Contreras during the day.

Since writing the foregoing I have found General Scott's report of this action. He describes the fire of artillery as *heavy*, the enemy having twenty-two guns mounted, to which we could only reply with a battery or two of six-pounders, and one of mountain howitzers. I doubt if all the enemy's guns were used, or could be brought to bear that afternoon. However, General Scott says in one place: "It was already dark, and the cold rain *had begun to fall in torrents* on our unsheltered troops." He afterwards refers to the night march of the troops being hindered by "mud and rain." I was under partial shelter that night, which may account for my recollections not being very clear of "torrents of rain."

The battle of Churubusco was fought the next day, which was bright and clear; I don't remember rain. The day after it rained heavily whilst we were on the march to Tacubaya. I do not remember with sufficient distinctness the condition of the weather

after other Mexican battles; nor, considering the nearness of the period named to the rainy season, are the above facts, perhaps, of great significance.

The 21st of July, 1861, the day of the battle of Bull Run, was clear, hot and bright all day long. The next afternoon there were "torrents of rain," which continued all night.

The battle of Gaines' Mill was fought June 27, 1862. It was a bright, clear day, as was also the 28th, but on the night of the 28th and morning of the 29th it rained heavily.

The 29th and 30th of June were fair, bright days. The battle of Malvern was fought July 1, a bright, clear day. During the night it commenced raining, and on the 2d and 3d, also, I think it poured down.

I do not remember that the battle of Antietam was followed by rain. It may have been; I do not remember. Nor can I speak positively as to that of Fredericksburg, December 11-13, 1862.

The battles of Chancellorsville, May 2–4, were fought, I believe, throughout in fair weather. In the afternoon of the day the army recrossed (5th) it poured rain—raising the river, sweeping off the bridges, so cutting off the movement until they could be restored—and continued all night and part of the next day.

The battle of Gettysburg was fought July 1, 2 and 3, in clear weather. On the 4th it rained furiously, and continued part of the 5th.

I do not remember that violent rain followed the battle of the Wilderness. There was not much artillery fire compared with the magnitude of the forces engaged. This was on the 5th and 6th. There was rain, I believe, on the 8th or 9th, during the first fight on the right at Spottsylvania C. H. After the heavy fighting there, the army on its move to the left, to renew the attack, did so through a heavy storm of rain, which continued next day.

The fighting, however, from the 4th of May to the 27th, when the army crossed the Pamunkey, was so continuous that little, if any, conclusion from the rains that happened in that period could be drawn, as affecting the question of *cause*.

As to the temperature and direction of the wind at these times, I cannot give you any information worth recording. The occurrence of rains soon after battles I have noticed frequently, but whether previous statements that such was often the case, or whether the frequency of the occurrence attracted my attention, I

cannot say. Frequently without means of keeping memoranda on pressing subjects, of course I had neither time nor opportunity to record such facts. Indeed, the necessity of trusting to memory for many things is what enables me to recall circumstances of time, place and weather that permit me to write this letter, which I fear you will not find very useful, but it is the best I can do to comply with your request. I regret exceedingly that I cannot do better. Very respectfully, your obedient servant,

HENRY J. HUNT, *Maj. Gen. Bvt.*
Late Chief of Artillery, Army of the Potomac.

No. 27.

From Brevet Brigadier General P. V. Hagner, of the Ordnance Department, U. S. A.

WATERVLIET ARSENAL, WEST TROY, N. Y., *Dec.* 28, 1870.
EDWARD POWERS, ESQ., Chicago:

Sir—I have received your note of the 24th, and respond with pleasure to your inquiries. I have no doubt that heavy firing of artillery is, almost invariably, soon succeeded by a fall of rain, and I think it will be proven that this effect is due to some other cause than the heat evolved in burning gunpowder. It would seem, also, pretty certain that a *second* spell of firing in the same vicinity will not produce a *second rainstorm* within a day or two (or more) after the first. You will have a good chance of deciding the exact amount of influence due to this by observing carefully the reports from the Prusso-French battle-fields. The matter is alluded to under the head of "Rain following the discharge of ordnance," in the "Annual of Scientific Discovery," page 392, year 1862, and page 333, year 1863.

All accounts of the battle of Waterloo tell of the heavy rains during that battle. The same is true of many others of Napoleon's battles.

About the battles of Mexico, concerning which you ask my remembrance, I can refer you to Henry B. Dawson's "Battles of the United States," where, on page 467, siege of Monterey, September 21, 1846, after a continuous engagement, "Soon after the storming of the two forts, Federacion and Soldado, a violent storm came up;" and page 468, "the men were exposed to the unbroken pelting of a pitiless storm during the night." Also page 473, "Gene-

ral Worth and second division, as has been seen, spent the night entirely exposed to the peltings of a severe storm."

Battle of Buena Vista, page 491, the firing commenced on the morning of the 22d of February, and "at night the cold wind and drizzling rain which chilled the bodies." But there was heavier firing on the 23d, while at night the "moon shone;" page 497.

Battle of Contreras, page 563: "The battle raged furiously, and for more than three hours the entire force was under fire. * * * Night at length put an end to the conflict, and a cold rain, which soon afterward began to fall in torrents,"—(as I well remember).

I am almost certain that in the afternoon and evening of the 8th of September, after the battle of Molino del Rey, there was a hard rain. It was clear until 1 or 2 o'clock, I remember.

We fired all day of the 12th of September, at Chepultepec, but not very rapidly (as we could not spare many shot). It was clear the 13th, but, I think, rained before night on the 12th. (I do not feel certain, however, and cannot now confirm my impression.) It was dark and cloudy the night of the 13th (when I was throwing some shells and shot from San Cosme Garita to let the Mexicans *feel where we were*), but bright enough the morning of the 14th, when we marched into the city.

I am sorry that I cannot be more definite in my information.

Very respectfully, sir, your obedient servant,

P. V. HAGNER.

General Hagner, in a subsequent letter, mentioned that he thinks he has a distinct recollection of rain which occurred after the battle of Chepultepec, between the time he was firing from the Garita of San Cosme and sunrise on the morning of the 14th.

No. 28.

From Major General Thos. J. Wood, U. S. A.

DAYTON, O., *Jan.* 9, 1871.

EDWARD POWERS, ESQ., Civil Engineer, Chicago, Ill.:

Dear Sir—Your note of the 28th ult., covering a slip from the Chicago *Post* written by you, is received.

The theory suggested by you of the relation of cause and effect between great atmospheric disturbances, such as are caused by the heavy cannonading in great battles and the occurrence of rain immediately afterwards, is not new; but the suggestion of a series of experiments, with a view to the determination, with reasonable satisfaction, whether the theory is true, for the purpose of making it practically useful, is novel and well worthy of consideration.

A collation of facts, drawn from many reliable sources, might well serve as the basis of further experiments.

Many battles, as all know who have had any experience on the subject, have been followed by rain, while others have not. This fact would seem to indicate that if the atmospheric disturbances caused by the firing in battle have any effect in producing rain, the actual accomplishment of rain depends, in a great measure, if not chiefly, on the condition of the atmosphere. The condition of the atmosphere should, hence, be one of the chief factors to be observed in the experiments you propose.

With these preliminary remarks, I will give you a few facts drawn from my own personal experience.

Battle of Monterey, September 23, 1846. Morning bright and fair, with no indications of rain. Heavy cannonading during the day. The evening and night closed in with heavy rain.

Battle of Contreras, August 19, 1847. Same remarks applicable as to battle of Monterey.

Battle of Shiloh, April 6, 1862. Same remarks as to Monterey.

Battle of Stone River, December 31, 1862. Much heavy cannonading, followed by sleet, snow and rain.

Battle of Nashville, December 15 and 16, 1864. Same remarks applicable as to battle of Stone River.

I might mention similar facts drawn from my own experience or historical reading, but these, with such as you will doubtlessly derive from like sources, will probably answer your purpose.

Very respectfully, etc., TH. J. WOOD,
Major General, U. S. Army.

No. 29.

From Major General R. W. Johnson, U. S. A.

ST. PAUL, MINN., *Jan.* 10, 1871.

My Dear Sir—Yours of the 28th ult., with enclosure, is received. Throughout the late war I had frequent occasion to observe that

heavy cannonading was soon followed by rain. I was present and engaged in the battles of Stone River, Liberty Gap, Chickamauga, Mission Ridge; the campaign to within three miles of Atlanta; and also the battle of Nashville. Heavy rains followed Stone River, Liberty Gap, Mission Ridge and Nashville. During the Atlanta campaign, which was a continuous battle of ninety days, we had heavy rains at short intervals. After the battle of Chickamauga no rain fell; but it must be remembered that this battle was fought in the woods, where artillery could not be handled easily, and there was but little cannonading on that field. It was so common for rain to succeed battles that I think it was generally conceded that these showers were brought about by the heavy firing.

In my own opinion I am satisfied that rain can be produced by a heavy cannonading. My own experience satisfies me, and I think the opinion became general during the war.

Your obedient servant,

R. W. JOHNSON,
Major General, U. S. A., retired.

No. 30.

From Major General Schuyler Hamilton, of New York.

NEW YORK CITY, *Jan.* 14, 1871.

EDW. POWERS, ESQ., Chicago, Ill.:

Dear Sir—Your favor of December 24, 1870, was only received yesterday. You will see by the enclosed envelope why. As to the subject of rain after heavy firing in battle, I can say as to Monterey that, though the day on which the battle commenced was in the morning bright and beautiful, a heavy rain fell in the evening, viz., September 21, 1846. I think the same phenomena was exhibited September 22 and 23. I was so grievously wounded at the time of the battles of Molino del Rey and Chepultepec, as to be unable to participate. However, at Mira Flores, the affair in which I was wounded, where the firing of small arms was very brisk for a time, a bright afternoon and day was followed by a heavy fall of rain. I have referred your note to Col. H. L. Scott, who was Chief-of-Staff and Adjutant General to Gen. Scott, in Mexico, asking him as to his recollections as to Molino del Rey and Chepultepec. I merely state my recollection as to the fact that rain fell on the occasions referred to by me. I think my observation

has been, wherever I have been engaged, that the concussion produced by the heavy fire of a battle has been invariably followed by rain. Such was the case after Palo Alto, Mex., also.

I remain your obedient servant,

SCHUYLER HAMILTON.

In referring the writer's inquiries to Colonel Scott, as General Hamilton was kind enough to do, the following correspondence ensued:

Col. H. L. Scott will oblige me by stating if he has any recollection about the weather after Molino del Rey and Chepultepec, Mex., as I wish to oblige the writer of enclosed by a simple statement of the fact of rain or no rain—leaving to him his theory.

Yours truly,

SCHUYLER HAMILTON,
Late Major General of Volunteers.

DEAR HAMILTON—I am unable to recollect whether it rained or not after Molino del Rey, and I probably should not be able to recollect how it was after Chepultepec and the City of Mexico, but in the "Mexican History of the War in Mexico" I find the following passage: "The morning of the 14th (September) was as gloomy and sad as the destiny of the Republic. There was a mist so thick that objects could not be seen at a few steps distance. Soon after a light shower began to fall, which soaked the soldiers, and the cold increased that was felt."

Truly yours,

H. L. SCOTT.

No. 31.

From Major General John C. Robinson, U. S. A.

BINGHAMTON, N. Y., *Jan.* 16, 1871.

EDW. POWERS, ESQ., Chicago:

Sir—Your favor of the 28th ult., forwarded from Washington, has been received. In reply I would say that I have not the slightest doubt of the correctness of the theory you mention. I have observed that all great battles in which I have been engaged (particularly those of several days' continuance) were followed by heavy

rains. Some of the battles in Mexico, the battles on the Chickahominy, the seven days' battles, the battle of Fredericksburg, and the battle of Gettysburg were immediately followed by very heavy rains. That heavy cannonading will produce rain, does not, in my opinion, admit of doubt.

Very respectfully, yours, etc.,

JOHN C. ROBINSON,
Major General, U. S. A.

No. 32.

From Major General J. M. Schofield, U. S. A.

SAN FRANCISCO, CALIFORNIA, *Jan.* 19, 1871.

MR. EDWARD POWERS, Chicago, Ill. :

Dear Sir—Your letter of October 15, has, unintentionally, been left unanswered until now. I cannot attempt to give, from memory, specific facts which would be of value to you, but the general fact of a fall of rain during or immediately following heavy discharges of artillery and musketry, has been, in my experience, so common, and regarded so much a matter of course, as to attract no special notice in individual cases. My impression has been, however, that this phenomenon results only when the quantity of moisture in the atmosphere approaches nearly the point of saturation, and when any considerable disturbance of equilibrium might naturally be expected to produce condensation. In a calm, moist atmosphere, heavy discharges of artillery are, I think, very generally followed immediately by a fall of rain. Beyond this my experience does not enable me to express an opinion.

The subject you have under consideration is one of much interest, and may prove to be of no little importance.

Very respectfully,

J. M. SCHOFIELD.

No. 33.

Extracts from a Letter from Major H. S. Melcher, dated Portland, Maine, Feb. 18, 1871.

"Antietam, September 17, 1862, was the first battle I was in. The first day's fighting was sharp, with heavy artillery firing;

the next day there was a very sudden and heavy shower of rain; had been none for five days previous."

"Alder, June 21, 1863. A general skirmish, with but little artillery. Next day foggy, with quite a fall of rain. Had been very dry for two weeks."

Major Melcher also mentions the rains after Fredricksburg, Chancellorsville, and Gettysburg; but as these are elsewhere sufficiently described, his description is omitted. In regard to the battle of Spottsylvania, he says: "A very heavy rain storm set in the night of the 10th.

Of subsequent battles:

"Being wounded, I did not rejoin the army till October, so that I cannot speak of the results of operations in front of Richmond and Petersburg; but at the battle of Dabney's Mills, February 6, 1865, where considerable artillery was used, afternoon of the 6th, a storm of rain and snow set in next morning."

"The first day's operations in front of Petersburg, which resulted in the fall of that place and final overthrow of the rebellion, was followed by a heavy rain storm, which continued all night and the day following."

No. 34.

From Colonel R. Kennicott, of Illinois.

CHICAGO, ILL., *Feb.* 22, 1871.

Dear Sir—Yours, of yesterday, is at hand. In reply I have the honor to state that I was at the battle of Pea Ridge, Ark. It did rain after that battle; I think the morning after, March 9, 1862, when a very heavy shower fell.

I did not march with the command up Red River, and did not belong to the army or armies engaged at the other places you mention, save at Vicksburg. I was present there from June 14 to the fall, but do not remember about the rainfalls, though I think there were several light showers. I think we had rain just after

Prairie Grove, and I have several times noticed that cannonading was followed by rain.

With regrets that I have no data with which to furnish you,

I am, sir, very respectfully yours,

R. KENNICOTT.

No. 35.

From Rear Admiral L. M. Goldsborough, U. S. Navy.

NAVY YARD, WASHINGTON, D. C., *Feb.* 25, 1871.

EDW. POWERS, ESQ.:

Dear Sir—In reply to yours of the 22d, received by the mail of yesterday, I have to say that my impression is quite decided upon the subject to which you advert, but it is impossible for me at this time to furnish you with the details you wish without a research which I have not now the time to make. It is my firm belief that, invariably, an early fall of rain follows a heavy firing of artillery, continued for a few hours in a limited district of space. It may be, however, that the phenomenon is more likely to occur on land than at sea; and I am inclined to think that such is the case.

As well as I can now recollect, rain occurred the next day after the bombardment of Roanoke Island, if not during the night of the same day, February, 1862. But to get the facts you want, with precision, I would commend you to consult our Log Books. They are carefully kept preserved in our Bureau of Navigation, and they give the weather, at short intervals, for every day of the year, recorded, too, in the most systematic manner. In a word, they will tell you, beyond all doubt or dispute, exactly what weather did occur after every naval engagement. * * * They are a source to which you should appeal for the most reliable information in regard to the subject you have in hand, which, to my apprehension, is fraught with interest, and can be worked up probably, to the advantage of science, if not to special benefit. Rain, for instance, as we all know, is the best of fertilizers; and a means within general reach may be discovered to cause it to descend when most wanted. Philosophy holds all things to be possible.

Very truly yours,

L. M. GOLDSBOROUGH,
Rear Admiral, U. S. Navy.

No. 36.

From General Julius White, of Illinois.

CHICAGO, ILL., *Feb.* 26, 1871.

EDWARD POWERS, ESQ., C. E.:

Dear Sir—In reply to your note of the 20th inst., asking the result of my observations, during the late war relative to the theory that rains are produced by the firing of artillery, I would state that the only marked instance within my recollection occurred in the month of August, 1864, at about the time the Weldon railroad was taken by the Fifth Corps, under General Warren.

During the fighting which ensued upon that event, say from the 18th to the 26th, within which there were two battles fought by the Fifth, and a part of the Ninth Corps, and one about five miles south by the Second Corps, I noticed and called the attention of some of the officers with whom I was associated, to the fact that the sun rose and set for a number of days upon skies which were free from clouds, yet the rain fell copiously during the nights.

It was regarded as remarkable, if not anomalous, and the theory to which you allude was somewhat discussed, at the time, in connection with the fact.

It is proper to state that there was one day (the 21st), when a heavy fog prevailed—brought to my recollection by the fact that the enemy attacked on that morning.

The effect upon the health of the troops, and especially upon my own, gave me further reason to remark the state of the weather, and I attribute a subsequent long sickness to the extreme heat during the days, and copious rains of the nights, during the period mentioned.

Very respectfully yours,

JULIUS WHITE.

No. 37.

Extract from a Letter from Commander E. Barrett, U. S. Navy, dated Ordnance Office, Navy Yard, New York, March 1, 1871.

"From boyhood I noticed that the atmosphere was affected by the firing of heavy ordnance. My attention was first attracted to

the subject in 1843 or 1844, in the harbor of Rio de Janeiro. We had had beautiful weather: a change was brought about by the arrival of the Princess of Naples, now Empress of Brazil. She was accompanied by the Neapolitan and Brazilian squadrons. On her arrival the fortifications and foreign squadrons began to fire. The firing continued for an hour or more, when the sky was suddenly obscured, and heavy showers followed. The next day was calm and partly overcast; as soon as the firing of salutes was renewed, the rain began to fall, and the breeze sprang up."

No. 38.

From Captain N. J. Manning, 23d Ohio Vol. Infantry.

BARNESVILLE, O., *Oct.* 31, 1870.

EDWARD POWERS, ESQ., Civil Engineer, Chicago, Ill.:

Sir—I noticed an article in the New York *Evening Post*, entitled "Artillery firing and rain," signed by you, and requesting the experience of any one who had observed the same; and I, in response to that, will give you some of my experience and observations.

I was a member of the 25th Ohio Vol. Infantry from the 10th of June, 1861, until the 27th of July, 1864, and participated in all the engagements the regiment was in between said dates (excepting the taking of Fort Wagner, on Morris Island, in front of Charleston, S. C.,) to wit: Cheat Mountain, Green Brier, Allegheny Summit, Monterey, Bull Pasture Mountain, in West Virginia; the pursuit of Jackson, by Fremont, up the Shenandoah Valley, which ended in the battle of Cross Keys; Cedar Mountain; Pope's retreat, which culminated in the second battle of Bull Run; Fredericksburg and Chancellorsville, in Virginia; and last, not least, the battle of Gettysburg, in Pennsylvania—in all of which engagements, or wherever there was artillery practice of any moment, I observed that rain fell either during the engagement or immediately thereafter, and the quantity of rain seemed to be in proportion to the amount of artillery firing, and I thought then, and I believe now, that the firing caused the rain.

The rain falling, on all the foregoing instances, without a single exception, convinced me that it could not be merely a coincidence, but that the rain was brought on by the firing, and I think there is

no doubt of it. I also heartily concur with you in your views that, in time of drouths, large amounts of money could be made to the country, at a little expense, by the use of powder in that manner.

Yours, respectfully,

N. J. MANNING,
Late Captain 25th O. V. I.

No. 39.

NEW YORK, *Oct.* 17, 1870.

Sir—I notice your article in to-day's *Telegram*, and believe its theory is correct. Have thought so since 1861, and my idea was confirmed by every heavy cannonading or musketry fire in my vicinity.

There were quite heavy rains very soon after the fight at Big Bethel, the naval battle in Hampton Roads between the Monitor and Merrimac, etc., etc., and the very severe battle at Malvern Hills.

It struck me as a curious fact that the amount of rain which fell after each battle, seemed to be very nearly in proportion to the amount of powder that was burnt.

Respectfully,

FRED. M. PATRICK,
Of 10th N. Y. Vol. Inft.

EDWARD POWERS, ESQ., Chicago, Ill.

No. 40.

From General E. W. Serrell, of New York.

OFFICE OF E. W. SERRELL, CIVIL ENGINEER,
64 AND 66 BROADWAY, NEW YORK, *Dec.* 9, 1870.

Sir—I am favored by your letter of the 28th ult., received to-day.

In reply to your request, permit me to say that, from my earliest recollection it was always understood that rain would follow the celebration of the 4th of July in this city when an unusual display was indulged in, and years ago your suggestion was considered, here, very reasonable. * * * * * *

In the Department of the South, during the war, so well was this thing understood, and the correctness of the theory recognized, that we always looked for rain after heavy cannonading, and at the bombardment of Morris Island, James Island, and several other places, rain followed by sundown or soon afterwards. I have not my army journal with me, but this I remember well, that both in the South and in Virginia, if rain did not follow a general engagement, we considered it the exception, not the rule; and I think most officers, especially engineers who keep journals, will agree with me, that such is their recorded experience.

Your obedient servant,

EDWARD W. SERRELL.

EDWARD POWERS, ESQ., Chicago, Ill.

No. 41.

From a Soldier of a Massachusetts Regiment.

RICHMOND, McHENRY Co., ILL., *Dec.* 26, 1870.

EDWARD POWERS, ESQ., Civil Engineer:

Dear Sir—In looking over the columns of a newspaper—*The Watchman and Reflector*—dated October, 1870, I chanced to see an article written over the above signature, making some suggestions, and, at the same time, inviting a statement of facts concerning the effect of the explosion of gunpowder on the atmosphere, in respect to rain, etc., etc. I will scan a three years' experience in the army with a condensation that might be styled "*multum in parvo.*"

I was a soldier in the war of 1861; member of a Massachusetts regiment; was in Gulf Department, and most of the time in Louisiana; was stationed on Ship Island three weeks. The troops, 13,000 strong, drilled six hours a day; at least two days in each week, the whole number were put through sham fights, in which some 30,000 rounds of blank cartridges were fired. The day following the first firing was foggy and cloudy; the succeeding night it rained hard. At the second drill of this sort only two brigades fired cartridges, and one battery fired a few rounds. In the night a heavy thunder storm arose, and three men were killed by lightning in one company. Though there was no more rain in the remaining days that we were on the Island, there was much dull weather.

During the bombardment of Forts Jackson and St. Phillip, we had much heavy weather, especially the last days of the bombardment; and, for several days thereafter, rain fell copiously. During, or soon after the various battles and skirmishes in which we were engaged, we almost invariably had heavy weather, and not unfrequently torrents of rain fell.

Up to end of first eighteen months service, though I kept a diary, I had not once thought of the probable cause of sudden changes in the weather, which, according to my diary, had occurred every time that the army moved from one position to another, and, as a consequence, became engaged with the enemy. My attention was first seriously attracted to the matter by repeatedly hearing superstitious soldiers, as I considered them, remark that fate was against us, because every time we moved we had to wallow in the mud; that we had pleasant weather in camp, but whenever we were set in motion "the rains descended, the floods came," etc., etc. Partly on account of superstitious gossip and gloomy predictions, and partly to gratify my own curiosity, I resolved, from this date to keep a clear and regular account of the weather, both in camp and in the field. I did keep a strict account, but the diary was afterwards burned on the steamer Washington,—so I am obliged to chronicle from memory. The storming of Fort Hudson, May 27, 1863, was followed by torrents of rain. There was much wet weather during the whole siege, extending far inland, and as far south as the Gulf. Immediately after the assault of June 14, there were several days of dull weather, and much rain.

On the Red River campaign, where there was continual fighting, for thirty-two days in succession, and several hard contested battles, there was much heavy weather. A heavy thunder storm generally followed the first or second day after a general engagement. This was especially the case where numerous batteries of artillery were brought into action. A severe engagement took place near the Atchafalaya River, La. When the battle began the sun shone clear—not a cloud in sight. Early in the evening the artillery of both contending armies opened a terrific cannonade, which lasted about three hours. Next morning, rain began to fall. The two armies met on the plains of Marksville. The result was a bloody and destructive encounter, followed by nearly a week of rain. This action took place in May, 1864. During my three years' exposure

as a soldier, I do not recollect of any considerable engagement not followed by heavy weather and rain. This result was invariably the case when numerous batteries of artillery were brought into action.

I have given a plain statement of facts upon a subject worthy the careful consideration and investigation of scientific men. Looking at this matter in the light of discoveries of the past, that have done so much to enlighten and benefit the human race, it certainly is not impossible, nor even improbable that, at no distant day, the elements may be so controlled that rain shall descend at the will of man.

I am sir, respectfully, your obedient servant,

MARSHALL M. CLOTHIER.

No. 42.

From J. A. MacGahan, a Celebrated War Correspondent, who was with the Russian Army in its Conquest of Khiva, Asia.

AMERICAN GEOGRAPHICAL SOCIETY, COOPER INSTITUTE,
NEW YORK, *Feb.* 28, 1874.

Dear Sir—Your letter of Feb. 9 only reached me a day or two ago, owing to my absence from the city, which will account for the delay in answering it.

In reply, I will say that the rain occurred some two weeks after the fall of Khiva and after the last artillery firing, which was tolerably incessant for a day, principally from pieces of four and six. This rain was what would be called in this country a light rain, which lasted a night. It would have been called a wet night.

The other was some time later, and commenced immediately on the lighting of a great number of fires in the Toorkman country by the Russians, who were burning the houses and wheat stacks of the Toorkmen. They burned a strip of country some four miles wide by fifty long in the space of four days. The rain only fell the first day. It was what would be called a "drizzle."

Hoping you may be able to use the facts I have herein communicated for the furtherance of science,

Believe me, I remain,

Yours truly,

J. A. MACGAHAN.

The following letter in the possession of the author is appended to show what has been the attitude towards this subject of certain distinguished men, some of whom are now no more. It may be said that they might have done more in aid of the project then, as now advocated, but under the circumstances it was much for them to do to thus publicly bear witness to the importance of the subject, and give encouragement for further efforts in its behalf. Doubtless they would have done more* had not the author, who was the originator and the only exponent and promoter of the proposed scheme to benefit humanity, himself laid it aside to wait for a more auspicious time. And whatever else may be said, the fact that such names as these are attached to this letter, however inconsequential that letter may appear, ought to place the subject above the reach of ridicule from smaller minds, if it does no more.

WASHINGTON, D. C., *Feb.* 17, 1874.

PROF. EDWARD POWERS:

Dear Sir—Having noticed that your recent lectures on the influence of artillery firing in producing rainfall have elicited some favorable comments from the press, and believing the matter to be of much interest to science, if not of practical importance to the country, we should be glad if you would afford those in this

*The newspapers state that Senator Farwell has caused to be inserted in the agricultural bill now pending in the United States Senate (August, 1890) an item appropriating two thousand dollars for experiments similar to those asked for by the author in his memorial to Congress, but differing from them in that dynamite is to be used instead of gunpowder, and is to be exploded at a great height above the earth. If this is true it shows that Mr. Farwell is convinced that there is something in this subject that is worthy of investigation, and that he has the courage of his convictions.

city who may be interested in the subject an opportunity to hear you upon it.

	C. B. FARWELL
JOHN P. C. SHANKS,	JOHN MCNULTA,
L. M. GOLDSBOROUGH,	J. A. GARFIELD,
M. H. CARPENTER,	I. CLEMENT.
JOHN COBURN,	JOHN A. LOGAN,
W. T. SHERMAN,	HORATIO KING.

The following reply to the above appeared in the Washington *Star* of Feb. 21, 1874, and in the *Chronicle* of the same date:

To the Hon. C. B. Farwell and others, Senators and Representatives in Congress, the General of the Army, Rear Admiral in the Navy, etc.:

GENTLEMEN:

I thank you for your invitation, and will say, in reply, that I have engaged to deliver my lecture on the subject to which you allude, on Monday evening, the 23d instant, under the auspices of the "American Union Academy of Literature, Science and Art," at the lecture room of the Young Men's Christian Association, in this city.

I am, yours very respectfully,

EDWARD POWERS.

WASHINGTON, D. C., Feb. 20, 1874.

The following brief synopsis of the lecture appeared in the *National Republican* of February 24, 1874:

At a special meeting of the American Union Academy of Literature, Science and Art, held last evening in the Chapel of the Young Men's Christian Association, Lincoln Hall, Dr. A. G. Mackey in the chair, and J. C. Will, secretary;

Prof. Edward Powers, of Chicago, delivered an able address on the influence of the firing of artillery in producing rainfall. The speaker, in the first part of his lecture, presented facts which he had been at much pains to collect from history, from the log-books of the navy, from correspondence with officers of the army

and from other sources, in relation to the weather following battles. These were so arranged as to make the evidence which they afforded cumulative. For example, some interesting facts were given to show that all great battles in which much artillery is used are followed immediately by rain. The mere fact that rain follows battles, however, is not conclusive that the battles cause the rain. But add to it the fact that the rain following such battles is almost always very heavy, and the evidence is strengthened; for the majority of the rains that occur in the ordinary course of nature are light ones. Proceeding then to a consideration of the rains following other engagements than great battles, circumstances are found that still further add to the probabilities that battles cause rain; and when it is also found that rain follows battles fought in a time of drouth, that it follows battles fought in the dry season in Mexico and salutes fired in the dry season on the Coromandel coast in India, and finally, that it follows battles fought in a country usually rainless the year round, the argument that battles cause rain becomes almost a demonstration.

In endeavoring to account for the production of rain by artillery firing, Mr. Powers totally rejects the theory of Espy, who, some thirty-five years ago, proposed to bring rain by building large fires. He considers the effect due, not to the formation of an upward current of air by heat, but to the action of concussion upon horizontal currents always existing above us. He refers to Maury's "Physical Geography of the Sea" for evidence going to show that there are above this continent two great atmospheric currents, the lower one of which flows from the southwestward, and brings from the Pacific Ocean the greater portion of the aqueous vapor that forms the rain that falls in the United States, and the upper one of which is a cold current flowing in nearly the opposite direction. The concussion of heavy artillery firing, he believes, rarefies the air in the lower and more humid of these currents and causes it to mix with the cold current above. Thus the cold of the upper current condenses the vapor of the lower, and clouds and rain are formed. This is consistent with the Huttonian theory of rain. Fire will also rarefy the humid current if the fire is large enough for the heat to rise to it; but this method of producing rain would be an exceedingly expensive and uncertain one.

The way in which heavy concussions rarefy the rain-bearing current, Mr. Powers believes, is by condensing, by its direct

action, a little of its vapor, and setting free the latent heat of this vapor.

The reason why a storm produced by a battle does not commence at the battlefield is, according to Mr. Powers' theory, that the rarefied air is carried away by the current before it has had time to mix with the cold air above. After the storm is well under way, however, the upper current will generally cause it to spread not only back to the battlefield, but also to a great distance on each side. The force of the latent heat evolved from the condensing vapor will also aid in widening the circle of the storm. Its principal motion, however, will probably be along with the vapor-bearing current.

Prof. M. F. Maury, in his "Physical Geography of the Sea," claims that the great atmospheric current from the southwest is a continuation of the southeast trade wind of the Pacific Ocean. This wind reaches from the surface of the ocean to the height, it is supposed, of three miles. It moves over the ocean for more than two thousand miles, and with slight interruptions, it blows perpetually.

At the equator it rises, and, as claimed by Maury, passes over the northeast trade wind ; then, coming nearer the ocean, it becomes the atmospheric current above mentioned. The amount of vapor which it takes up from the ocean and precipitates as rain on land and sea in the northern hemisphere is exceedingly great. Mr. Powers places these facts alongside of the facts developed by his investigations in relation to the occurrence of rains after battles, and argues that there is always an abundance of aqueous vapor above us, whatever may be the condition of the air at the earth's surface. In a time of drouth, the vapor-bearing currents are uninterrupted as they flow over the country, and the vapor is carried off to form rain in the Northern Atlantic and snow in the Polar regions. But we need not allow it to so go to waste. When the influences which nature has provided to cause disturbances in those currents fail to act, we can produce the required disturbance in them by the firing of artillery, and so bring rain in any quantities desired.

SELECTED ARTICLE.

From the "Golden Age" for the week ending May 11, 1872.

THE ARTIFICIAL PRODUCTION OF RAIN.

BY EDWARD POWERS.

That man should possess the means of bringing rain at will, has become one of the necessities of the world. The drouth comes on our fields, and the labors of the husbandman are brought to naught. It prepares our cities for conflagrations, and the work of years is swept away in a day. It dries to tinder the vegetable accumulations composing the soil in our forests, so that the fire creeps stealthily over vast tracts, ready, when the hurricane comes, to light up the whole in a conflagration which overwhelms all whose homes lie in its devouring track. And yet we make no effort, by striking at drouth itself, to prevent a recurrence of these disasters. While, in some fields of effort, the present age has gone forward with vast strides in the development of nature's resources, we are still, in respect to one vital matter on which the prosperity and even the very life of nations depend, subject to chance or the caprice of ever-changing circumstances. With an atmosphere around us containing a vast ocean of aqueous vapor—with air currents above us bearing rivers of moisture from the tropics and over the sea—we make no effort to produce those conditions which will cause the needed portions of that moisture to fall and water the parched earth.

Indeed, so chimerical seems the idea that such a thing is even possible that, when advanced, it is dismissed as the vagary of a dreamer. In no way, it is thought, can man influence the rainfall except by prayer to the Almighty. He alone, it is believed, can bring the lightning and the thunder and the rain. He giveth and he withholdeth the showers when and where he will, and vainly would man seek to wield a power that belongs to him alone. But how short-sighted is the philosophy or religion which concludes that, because a wise and beneficent Providence has so arranged the forces of nature that the earth is refreshed with rain from time to time without the volition or aid of man, it was never designed that man should control these forces so that they would minister more fully to his welfare. As well say that because the earth, in its pristine wildness, produced fruits for his sustenance, it was therefore never designed that he should plant nor dig nor prune in order to obtain

them in better quality and greater abundance. Nature, unaided, gives us fruits, and the savage seeks not to increase the supply nor to render it unfailing from year to year; so nature gives us rain—and while to the savage what is thus given may be sufficient, it is not so to civilized man—unequally distributed as it is—irregular in its times and uncertain in its amounts. And why should we expect that heaven would freely give us from the air what we require from that source, while withholding from us what we need from the earth except as the reward of toil and effort.

But these would be vain words were there not reason to believe that a means exists by which we might, if we would, bring down supplies of rain whenever and wherever needed. These means cannot now be fully explained; the plan requires experiments to test and develop it; but never in the first steps toward any of the great discoveries which the world has made, was there greater promise of results than there is in this; and there seems but little room for doubt that a way could be worked out by which we might have rain at will if man could but be induced to follow up the indications that point the way to so grand an achievement. Heavy rain almost invariably follows great battles—the natural conclusion from which fact is, that great noises are among the conditions which cause condensation of aqueous vapor in the formation of rain. That artillery firing under a cloudless sky can be made to cause condensation of clouds and rain from the aqueous vapor in the air, I believe can be proved beyond a shadow of doubt, if Congress would but grant the powder, cannon, and other appliances necessary to perform the experiment. One experiment, it is true, might not develop a method for obtaining rain at will and at moderate expense, but if successful in obtaining it at all it would be the first step in the solution of the great problem.

If great noises will cause rain, some other less expensive way may be devised to produce them. It was noticed, even in ancient times, that great rains followed battles—and it is not impossible that the shouts of a great multitude, with the clashing of metal on metal, may produce the same effect upon the air as the firing of cannon. Should all the inhabitants of a city at a given hour unite in creating an uproar with hands and voices, it would seem to one in our day as though the world were returning to barbarism; but in the higher civilization of some age to come, this may perhaps be a common occurrence.

But the experiment with cannon is suited to the present age, and shall it not be tried? There are many among the most intelligent in the land who believe that battles cause rain—and in the influence of that belief is the greatest hope that such an experiment will be authorized. Yet I fear that with all the promise of results which it holds out, such an experiment will never be undertaken until a few more lands have been desolated with famine, until a few more cities have been reduced to ashes, or until more forests, with villages and their inhabitants,* have become food for the devouring element. But he who doubts that man will yet control the rain so that it shall come at his command, has but a contracted and short-sighted view of the triumphs over nature which await the race in the future.

* Allusion is made here to the forest fire which swept over the village of Peshtigo, Wis., and the surrounding country, in 1871, and in which it was estimated that about a thousand people lost their lives. There had before been a similar fire at Miramichi in New Brunswick, and there has been one in Michigan since this article was written; both very destructive to property and to human life

APPROXIMATE ESTIMATE

OF THE COST OF THE TWO FIRST EXPERIMENTS AS PROPOSED FOR BRINGING RAIN.

In presenting an estimate of the cost of two such experiments as the author recommends as the most suitable for the first trials for producing rain, it may be premised that there are, in the United States arsenal at Rock Island, Illinois, several hundred field and siege guns of various calibers. This includes serviceable, unserviceable and obsolete guns. The number of gun carriages is not quite so great as the number of guns, but probably there are many more than enough for the desired purpose. The guns are mostly dismounted and it would cost to mount them, about five dollars for each field piece and about ten dollars for each siege gun that might be employed. The charge of powder for guns of different caliber is as follows:

For 30 pound Parrott	4 lbs.
" 100 " "	10 "
" 200 " "	16 "
" 300 " "	25 "
" 8-inch siege Howitzer	4 "
" 8-inch smooth bore gun	16 "
" 10-inch " " "	25 "

The kind of powder suitable for the purpose is worth about twenty-five cents per pound. It is be-

lieved that with 200 siege guns of various calibers and with plenty of cartridges containing an average charge of ten pounds of powder each, we could make all the noise that would be necessary to accomplish the purpose desired. It is assumed in the following estimate, that the experiments would be performed under the direction of the Agricultural Department, the War Department being asked for nothing but the loan of the guns and for a few weather telegrams. Probably the latter department would be glad if it could get rid, permanently, of its obsolete guns, as they are useless for any other purpose than to make a noise and bring rain.

It may be asked, "Why estimate for two experiments; why would not one experiment be equally satisfactory as an initiatory step in the proposed direction?" Because it is important to determine, not only whether or not we can originate a storm when no storm is reported by the Signal Service as in motion from the West, but also whether or not a Signal Service storm can be made to deviate from its natural course.

ESTIMATE.

Mounting 200 siege guns at $10 each,	$ 2,000
Railway transportation for 200 siege guns at $40 each,	8,000
40,000 blank cartridges at $2.50 each,	100,000
Fifty tons hay for wadding at $12 per ton,	600
10,000 electric primers at $150 per M.	1,500
Electrical battery and insulated wire,	500
Services of 10 men 26 days at $2.50 per day,	650

Services of 600 men 26 days at $1.50 per day,	$23,400
Rent of grounds for experiments,	250
Return transportation of guns to arsenal,	8,000
Dismounting and putting away guns at arsenal,	2,000
	$146,900
Add 10 per cent. for contingencies,	14,690
Total,	$161,590
Estimated cost of each experiment,	$ 80,795

Even if every good rain storm produced artificially should cost as much as above estimated for one of the preliminary experiments, such cost would be insignificant compared with its value; for a rainstorm is oftentimes worth millions of dollars to the country. But the cost will be much less than that after the Agricultural Department shall have brought the system to perfection and shall have established its stations and equipped them with artillery and other necessary appliances. The following is an estimate of the supposed cost of a good rain storm under such circumstances:

6,000 blank cartridges at $2.50,	$15,000
7½ tons hay for wadding at $12,	90
Electrical supplies,	800
Wages of 1 man 10 days,	50
Wages of 1 man 10 days,	30
Wages of 300 men 10 days,	3,000
	$18,970
Add 10 per cent. for contingencies,	1,897
Total,	$20,867

The above is on the supposition that the men will be employed permanently, and that, on an average,

three rain storms will be produced per month at any station. The number of stations for the whole country would probably be very few, unless needed for the control of cyclone weather.

In case the Agricultural Department of the Government shall have, by 1893, perfected the system of producing rain artificially, the author would suggest that the manner of doing this would be something new to show to the foreign visitors to the World's Columbian Exposition. As, however, the cost of producing a storm for their entertainment would probably be about ten thousand dollars more than the amount last above estimated, by reason of the additional heavy items of expense that would be incurred in the transportation of guns and men from the nearest government station to the vicinity of Chicago; and as the guns could not be brought very near to the city owing to the danger of breaking all the windows in the exposition buildings by the concussions, the better plan would be to let those who might desire to see how the elements of nature are made to obey the will of man, visit such station at a time when the department in charge shall decide that a rain is needed.